

# FROST-2014 – first experiences of deterministic Harmonie in the Sochi region

*Sami Niemelä, Evgeny Atlaskin, Sigbritt Näsman and  
Pertti Nurmi  
FMI*

HIRLAM ASM / ALADIN WS 2013  
Reykjavik, Iceland.  
15 – 18 April 2013

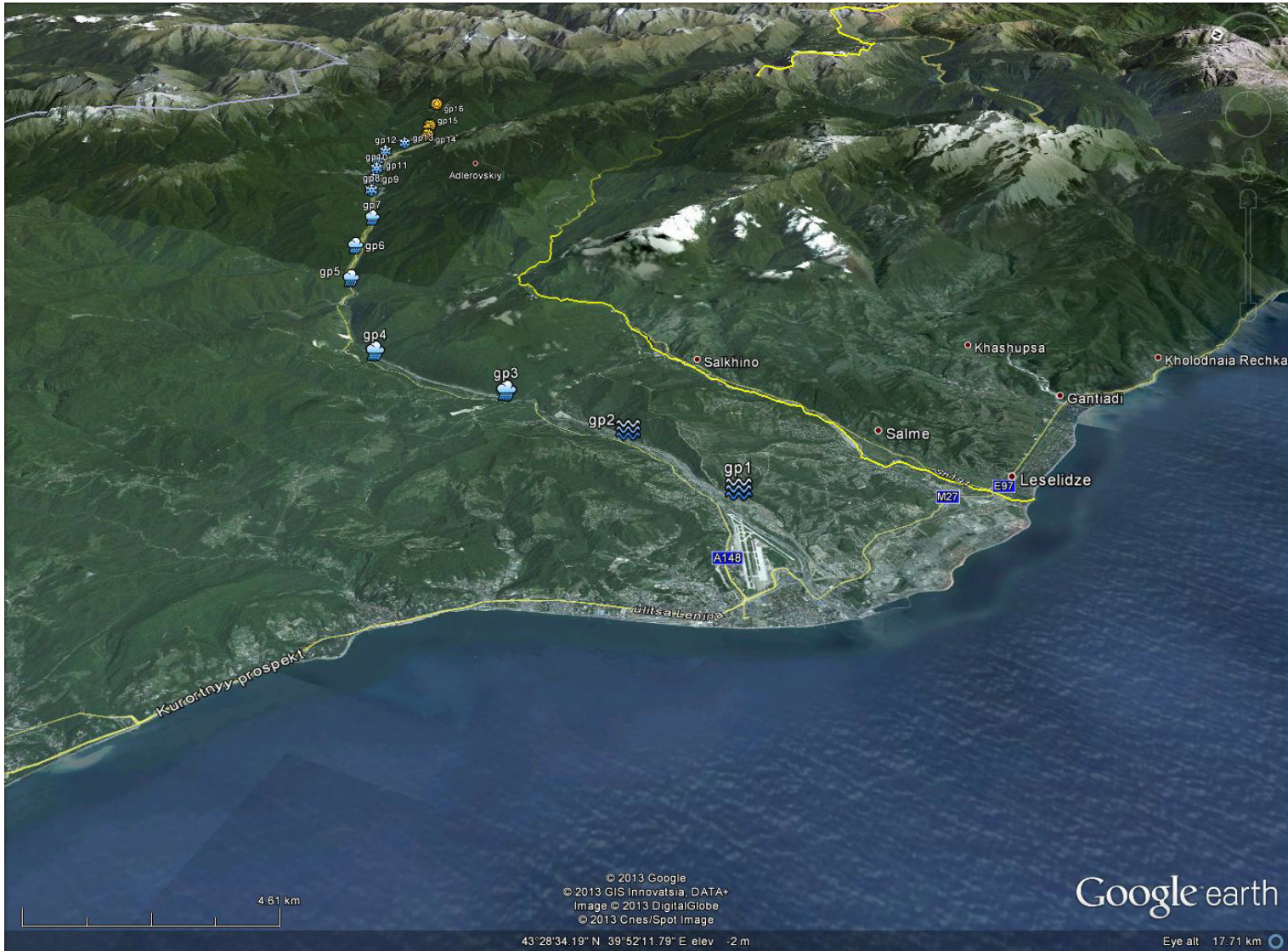


# Outline

- Winter Olympics 2014 in Sochi – characteristics of the region
- Harmonie comparison experiments:
  - *meso-scale baseline vs. regional/global model?*
  - *elevation datasets: GTOPO30 vs. SRTM?*
  - *effect of high resolution?*
- Summary and future actions before winter 2014.

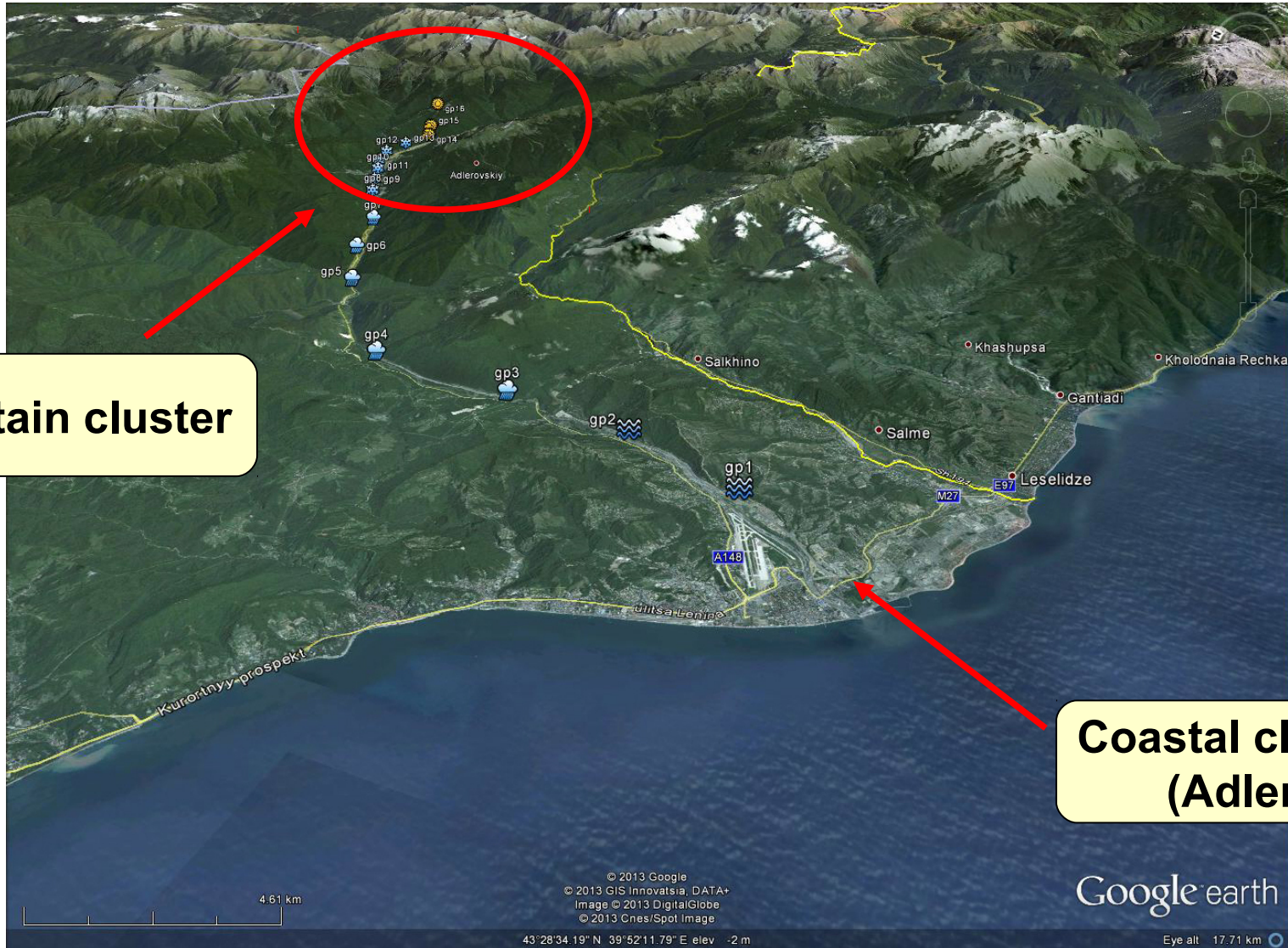


# Sochi region





# Sochi region



**Mountain cluster**

**Coastal cluster  
(Adler)**





# Sochi region







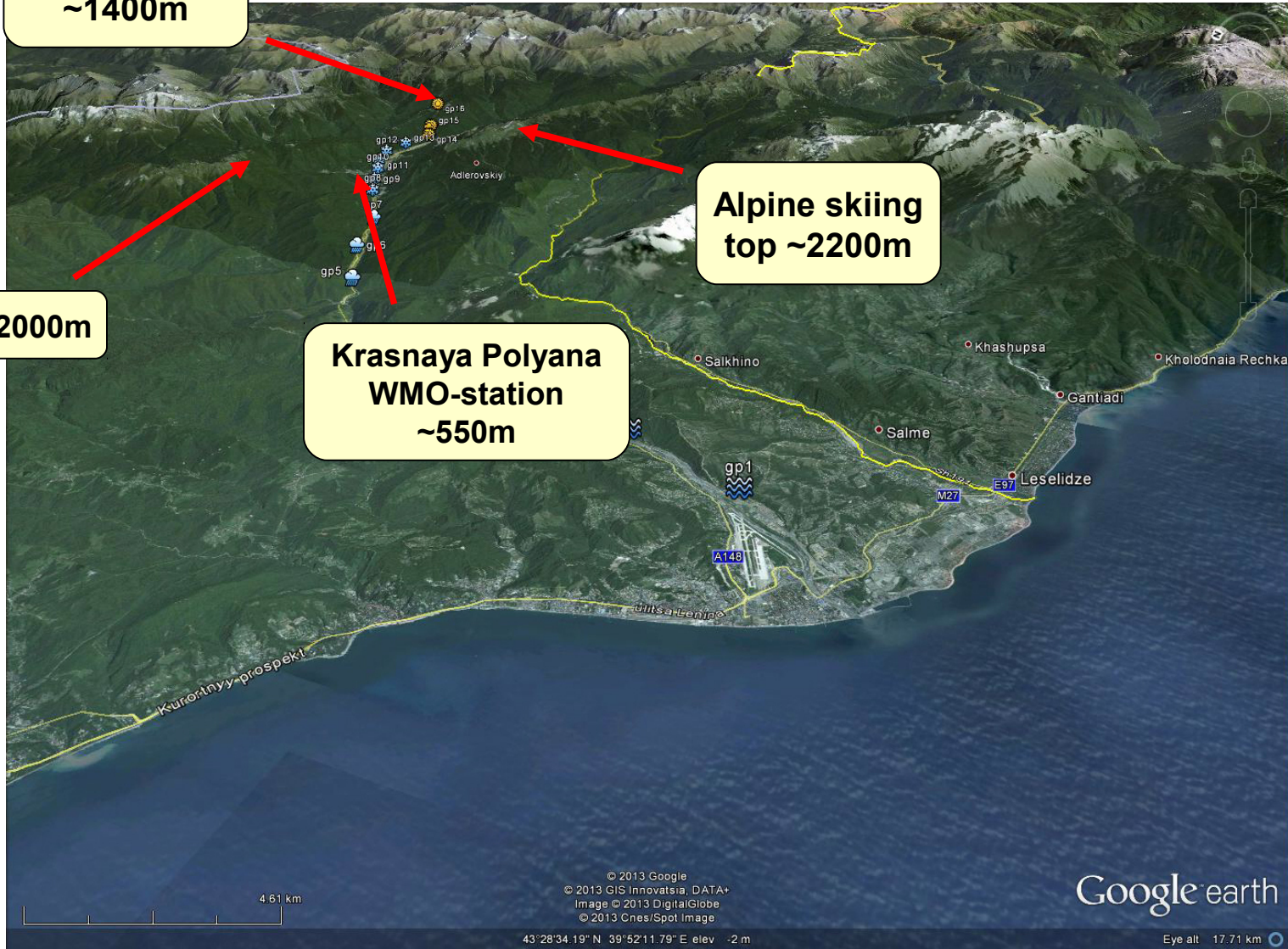
# Sochi region

Ski stadium  
~1400m

top ~2000m

Alpine skiing  
top ~2200m

Krasnaya Polyana  
WMO-station  
~550m

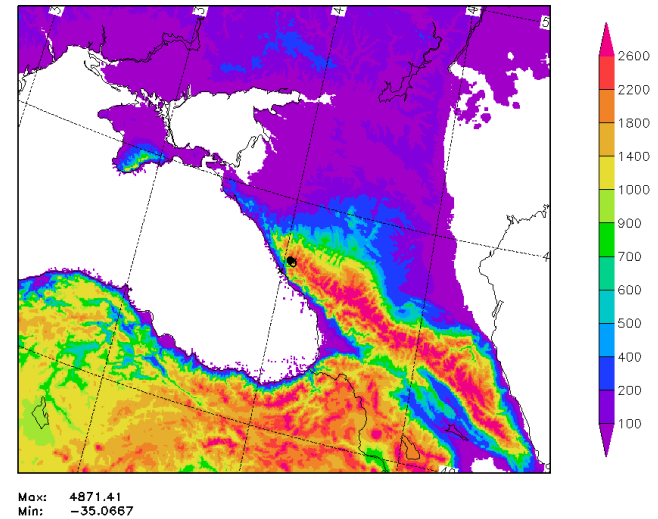


# Harmonie configurations

## • Baseline – setup (aro37h12)

- Version cy37h1.2
- Non-hydrostatic with AROME-physics
- **2.5 km grid size** (640 x 500)
- **time-step 60s**
- 65 levels in vertical (20 in lowest 1 km).
- data assimilation: 3D-Var for upper air, OI for surface
  - 6h assimilation interval
  - Jb calculated by using ensemble method.
  - conventional observations
- Hourly boundary conditions: ECMWF-IFS
- Orography data: SRTM (Shuttle Radar Topography Mission)
- Running period: Jan 2013

HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
31DEC2012 18:00 UTC (soc37h12,2.5km)



# Harmonie configurations

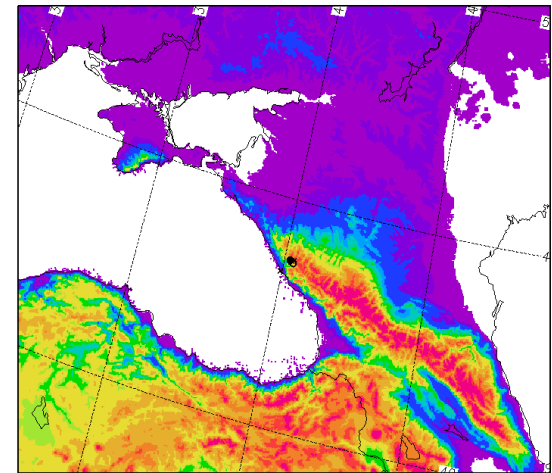
## • Baseline – setup (aro37h12)

- Version cy37h1.2
- Non-hydrostatic with AROME-physics
- **2.5 km grid size** (640 x 500)
- **time-step 60s**
- 65 levels in vertical (20 in lowest 1 km).
- data assimilation: 3D-Var for upper air, OI for surface
  - 6h assimilation interval
  - Jb calculated by using ensemble method.
  - conventional observations
- Hourly boundary conditions: ECMWF-IFS
- Orography data: SRTM (Shuttle Radar Topography Mission)
- Running period: Jan 2013

## • Orography test (aro37h12old)

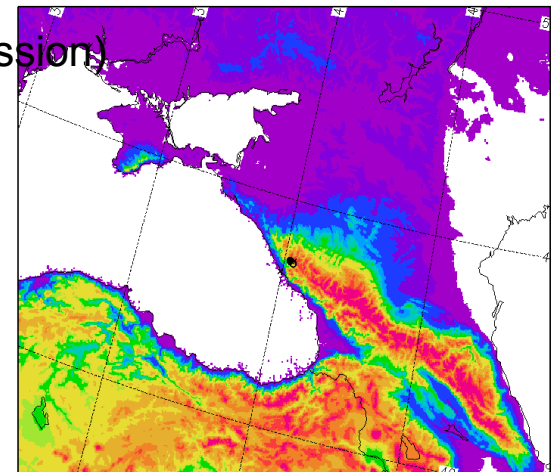
- Same as baseline
- Orography data: GTOPO30 (default in Harmonie)

HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
31DEC2012 18:00 UTC (soc37h12,2.5km)



Max: 4871.41  
Min: -35.0667

HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
31DEC2012 18:00 UTC (soc37h12\_old,2.5km)



Max: 4886.76  
Min: -34.9488





# Harmonie configurations

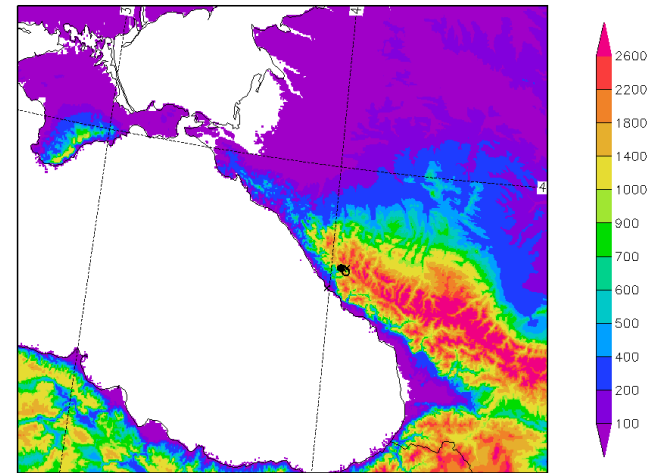
- **High resolution 1.5 km (aro37h12\_15)**

- Same as baseline
- **1.5 km grid size (640 x 500)**
- **Time-step 30 – 40s**
- Jb interpolated from baseline
- Running period: Jan – Mar 2013

- **High resolution 1.0 km (aro37h12\_10)**

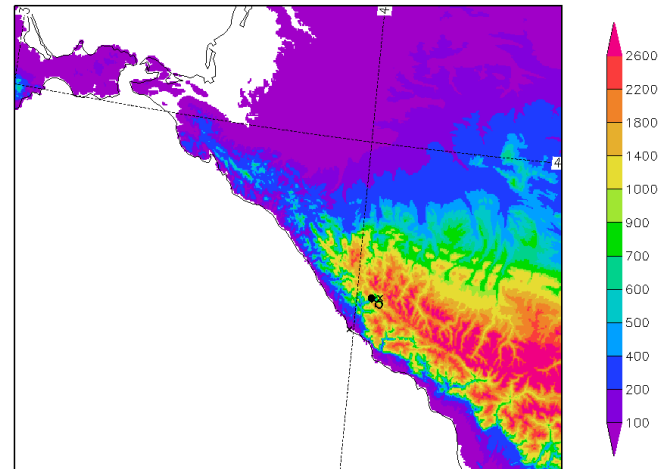
- Same as baseline
- **1.0 km grid size (640 x 500)**
- **Time-step 15 – 30s**
- Jb interpolated from baseline
- Running period: Jan – Mar 2013

HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
31DEC2012 18:00 UTC (soc37h12\_15,1.5km)



Max: 5159.22  
Min: -35.4783

HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
31DEC2012 18:00 UTC (soc37h12\_10,1km)



Max: 5357.32  
Min: -19.5967

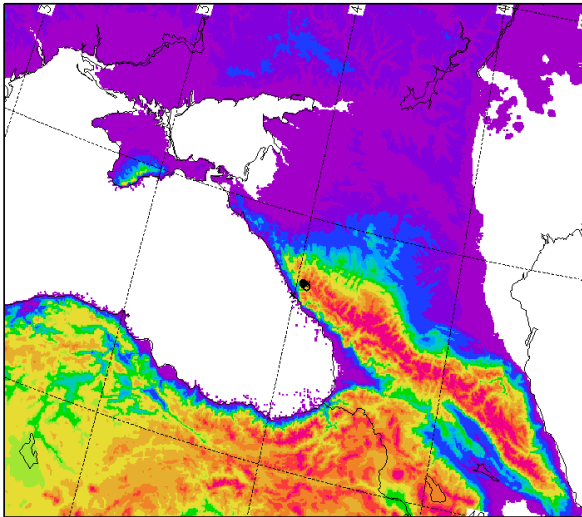


# Comparison experiments (1/3)

*Baseline vs. operational models (Hirlam & IFS)*

## HARMONIE 2.5km (soc37h12)

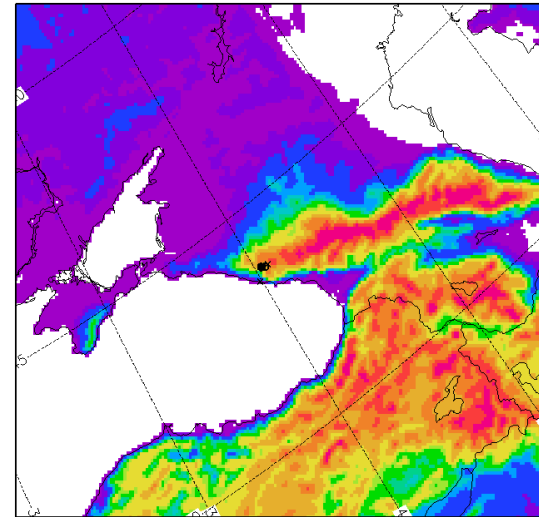
HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
31DEC2012 18:00 UTC (soc37h12,2.5km)



Max: 4871.41  
Min: -35.0667

## HIRLAM 7.5km (V74)

HIRLAM 04APR2013 00 UTC. Orographic height [m]  
04APR2013 06:00 UTC (V74,7.5km)



Max: 3578.87  
Min: -129.994

## ECMWF 16km (IFS)

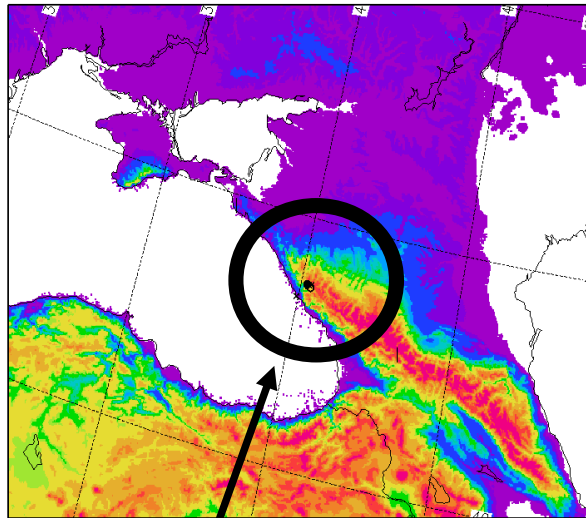


# Comparison experiments (1/3)

*Baseline vs. operational models (Hirlam & IFS)*

## HARMONIE 2.5km (soc37h12)

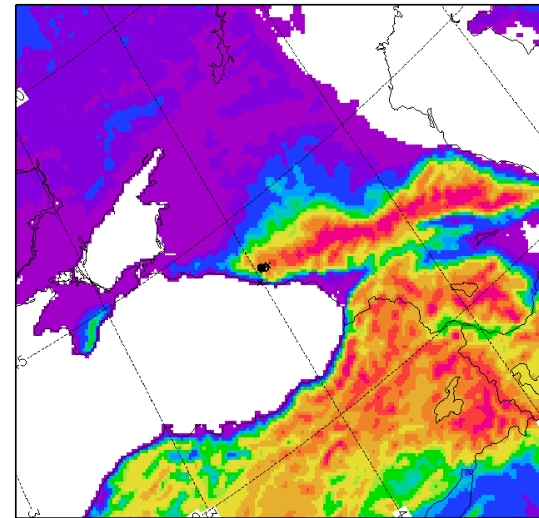
HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
31DEC2012 18:00 UTC (soc37h12,2.5km)



Max: 4871.41  
Min: -35.0667

## HIRLAM 7.5km (V74)

HIRLAM 04APR2013 00 UTC. Orographic height [m]  
04APR2013 06:00 UTC (V74,7.5km)



Max: 3578.87  
Min: -129.994

*Focus on Sochi area:  
~10 – 12 WMO stations*

**ECMWF 16km (IFS)**

# Comparison experiments (1/3)

*Baseline vs. operational models (Hirlam & IFS)*

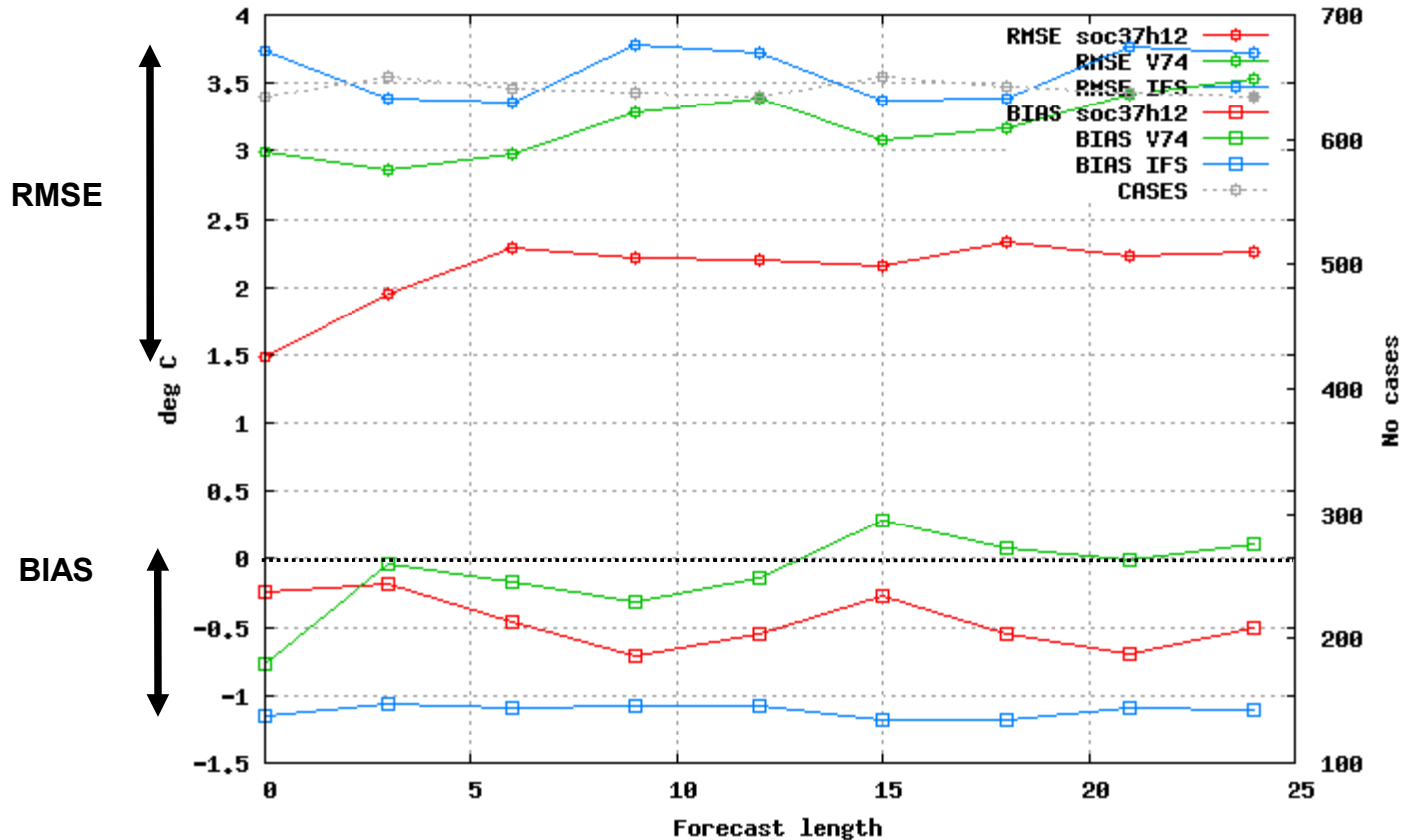
**HARMONIE – 2.5km**

**HIRLAM – 7.5km**

**IFS – 16km**

## 2m-temperature, Sochi area, Jan 2013

Selection: SochiArea\_BL using 11 stations  
 Period: 201301  
 T2m Hours: {00,12}





# Comparison experiments (1/3)

*Baseline vs. operational models (Hirlam & IFS)*

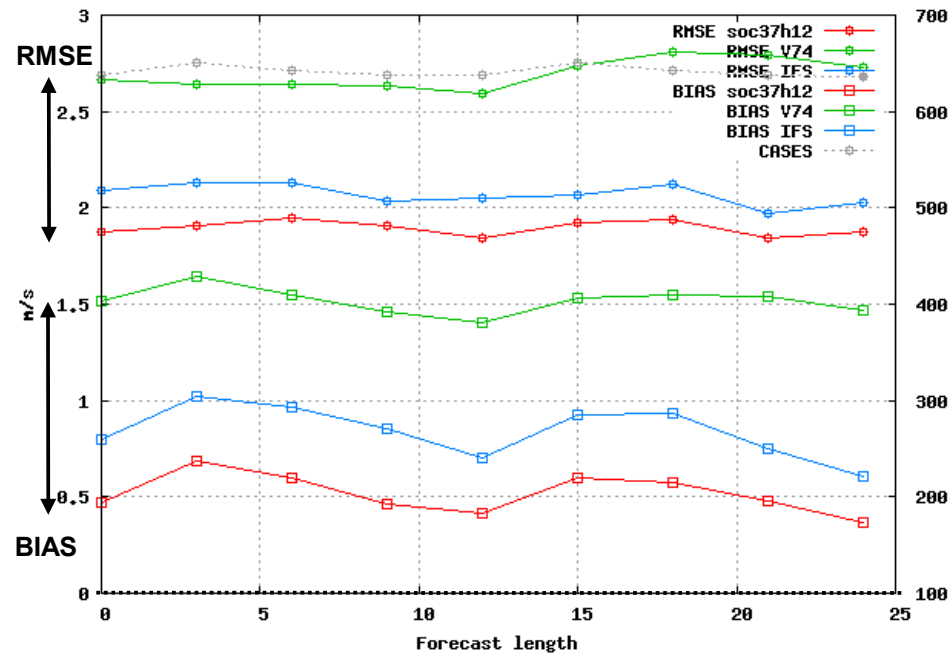
**HARMONIE – 2.5km**

**HIRLAM – 7.5km**

**IFS – 16km**

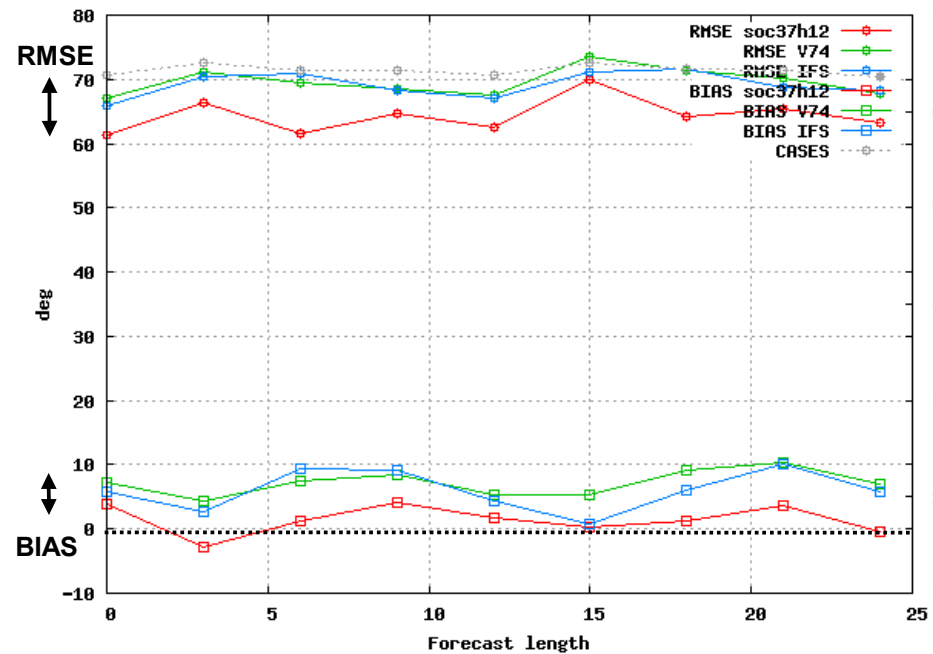
## 10m wind speed, Sochi area, Jan 2013

Selection: SochiArea\_BL using 12 stations  
 Period: 201301  
 U10m Hours: {00,12}



## 10m wind direction, Sochi area, Jan 2013

Selection: SochiArea\_BL using 12 stations  
 Period: 201301  
 Wind direction Hours: {00,12}



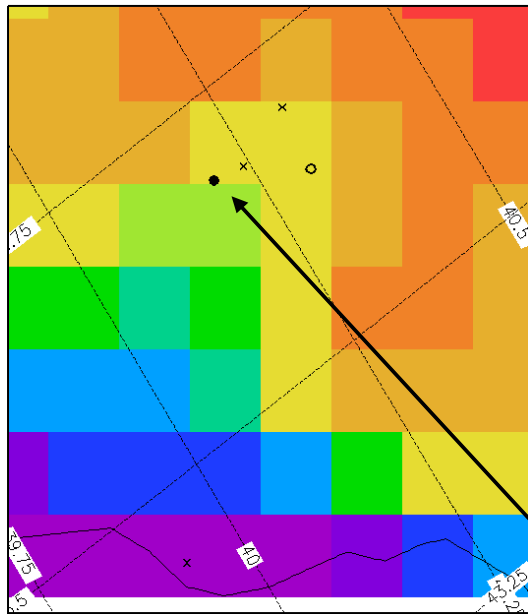


# Comparison experiments (1/3)

*Baseline vs. operational models (Hirlam & IFS)*

## Hirlam (7.5km) orography

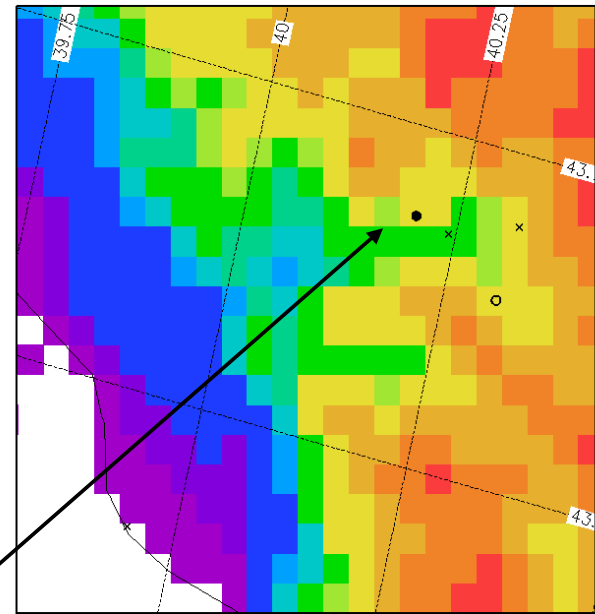
HIRLAM 04APR2013 00 UTC. Orographic height [m]  
04APR2013 06:00 UTC (V74,7.5km)



Max: 2358.9    Skiing: 1386m    Combined: 1339m    KrasnayaPolyana: 1339m  
Min: 0.48522

## Harmonie (2.5km) orography

HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
31DEC2012 18:00 UTC (soc37h12,2.5km)



Max: 2568.5    Skiing: 1208m    Combined: 809m    KrasnayaPolyana: 1009m  
Min: -19.2884

**Krasnaya Polyana (WMO-station)**



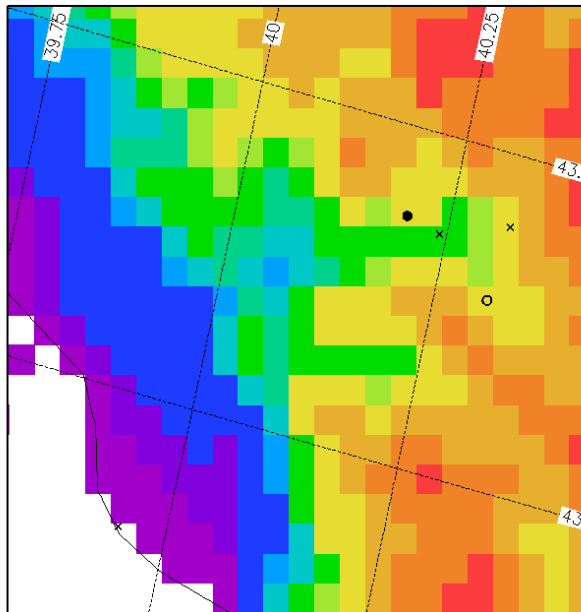


# Comparison experiments (2/3)

*Orography datasets: SRTM (baseline) vs. GTOPO30*

## 2.5km – SRTM (soc37h12)

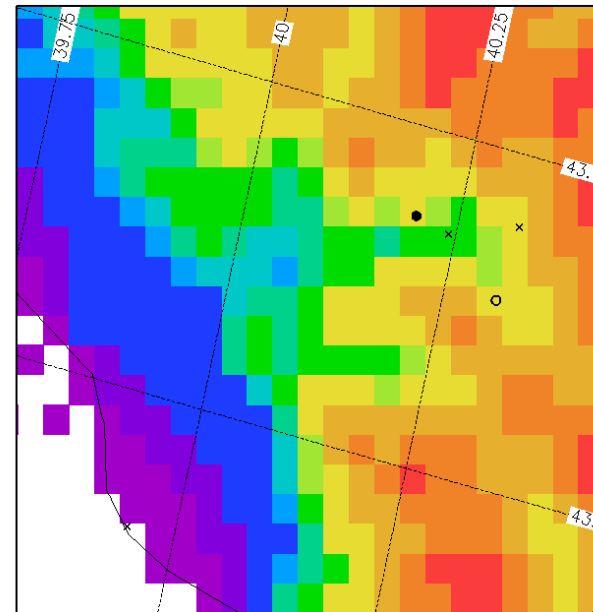
HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
31DEC2012 18:00 UTC (soc37h12,2.5km)



Max: 2568.5    Skiing: 1208m    Combined: 809m    KrasnayaPolyana: 1009m  
Min: -19.2884

## 2.5km – GTOPO (soc37h12\_old)

HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
31DEC2012 18:00 UTC (soc37h12\_old,2.5km)



Max: 2592.6    Skiing: 1286m    Combined: 802m    KrasnayaPolyana: 1000m  
Min: -19.0137

# Comparison experiments (2/3)

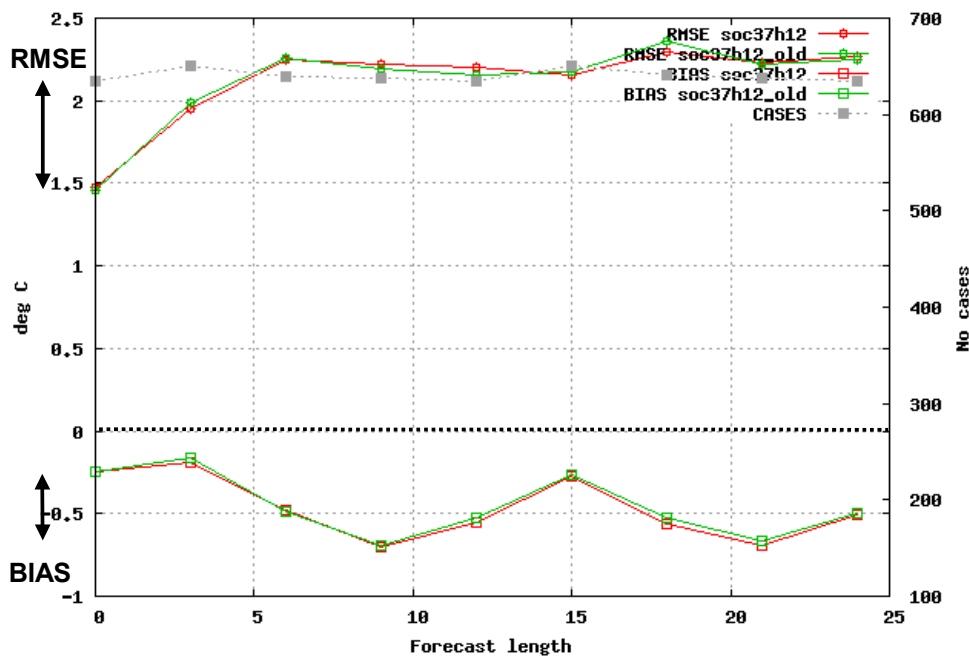
*Orography datasets: SRTM (baseline) vs. GTOPO30*

**HARMONIE with SRTM – 2.5km**

**HARMONIE with GTOPO – 2.5km**

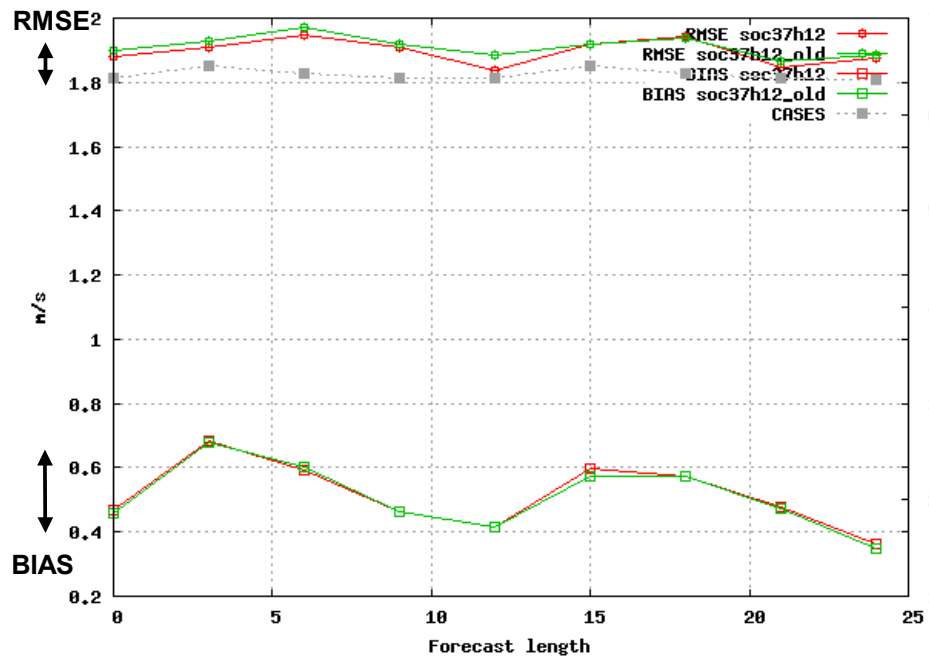
## 2m temperature, Sochi area, Jan 2013

Selection: SochiArea\_BL using 11 stations  
 Period: 201301  
 T2m Hours: {00,12}



## 10m wind speed, Sochi area, Jan 2013

Selection: SochiArea\_BL using 12 stations  
 Period: 201301  
 U10m Hours: {00,12}





# Comparison experiments (3/3)

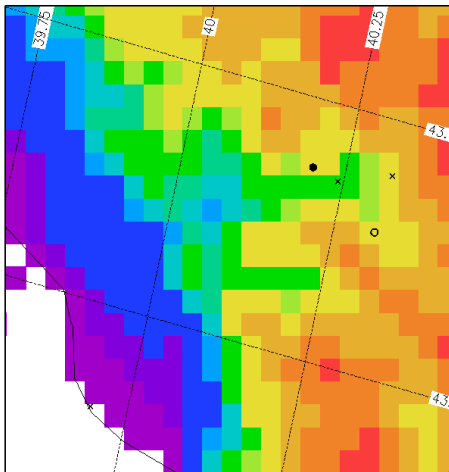
*Effect of high resolution?*

## 2.5km (soc37h12)

## 1.5km (soc37h12\_15)

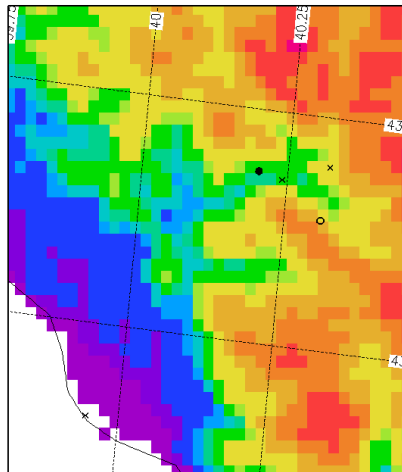
## 1.0km (soc37h12\_10)

HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
 31DEC2012 18:00 UTC (soc37h12,2.5km)



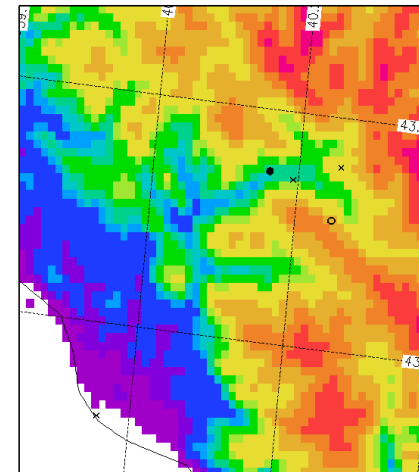
Max: 2568.5 Skiing: 1208m Combined: 809m KrasnayaPolyana: 1009m  
 Min: -19.2884

HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
 31DEC2012 18:00 UTC (soc37h12\_15,1.5km)



Max: 2728.11 Skiing: 1318m Combined: 722m KrasnayaPolyana: 776m  
 Min: -9.94847

HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
 31DEC2012 18:00 UTC (soc37h12\_10,1km)



Max: 2841.85 Skiing: 1360m Combined: 664m KrasnayaPolyana: 654m  
 Min: -6.43268

# Comparison experiments (3/3)

*Effect of high resolution?*

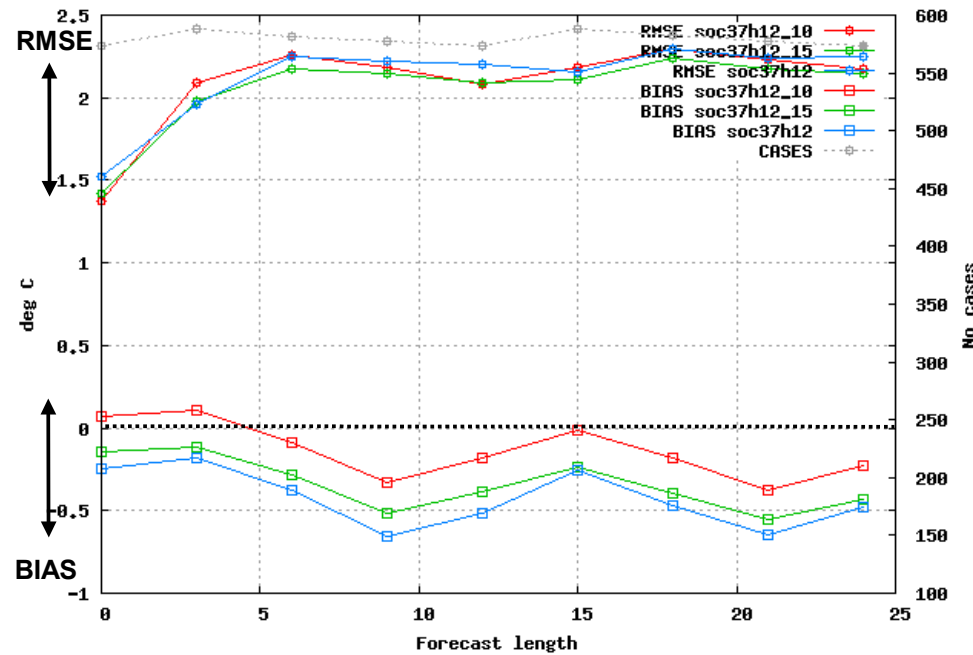
**HARMONIE – 1.0km**

**HARMONIE – 1.5km**

**HARMONIE – 2.5km**

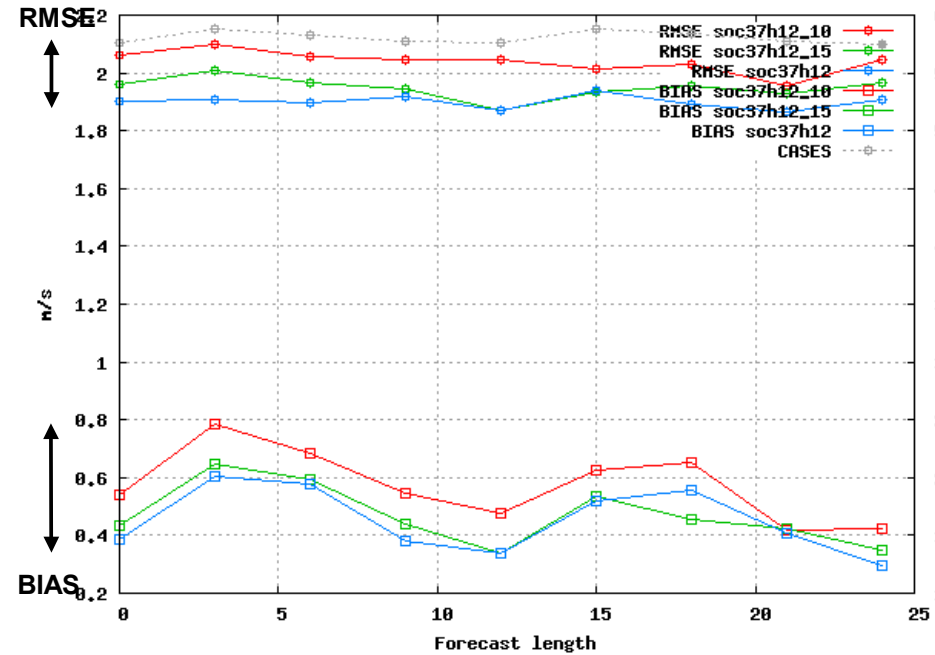
## 2m temperature, Sochi area, Jan 2013

Selection: SochiArea\_BL using 10 stations  
 Period: 201301  
 T2m Hours: {00,12}



## 10m wind speed, Sochi area, Jan 2013

Selection: SochiArea\_BL using 11 stations  
 Period: 201301  
 U10m Hours: {00,12}





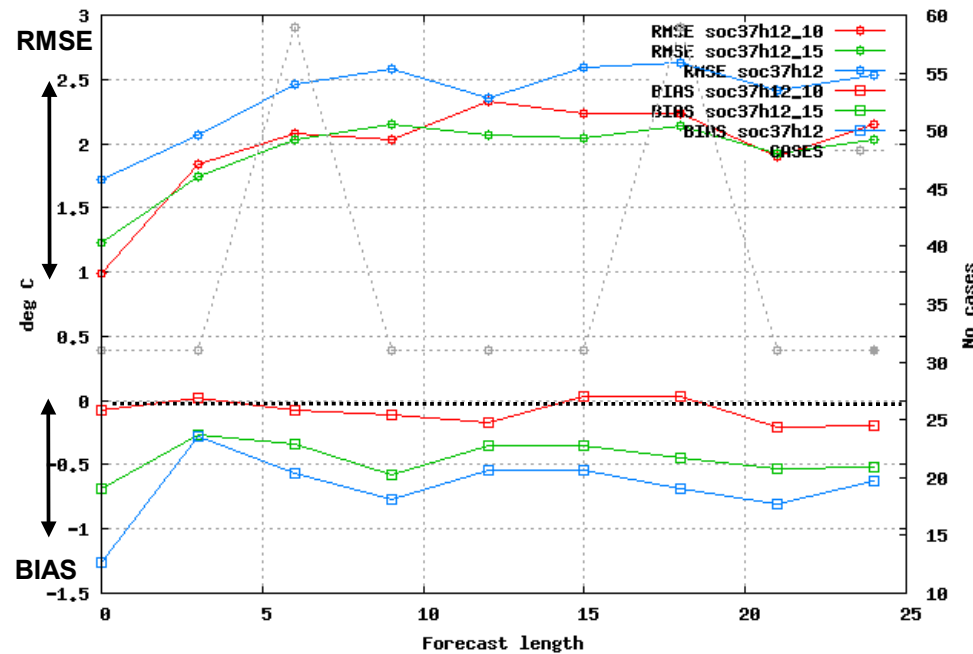
# Comparison experiments (3/3)

*Effect of high resolution?*

**HARMONIE – 1.0km**  
**HARMONIE – 1.5km**  
**HARMONIE – 2.5km**

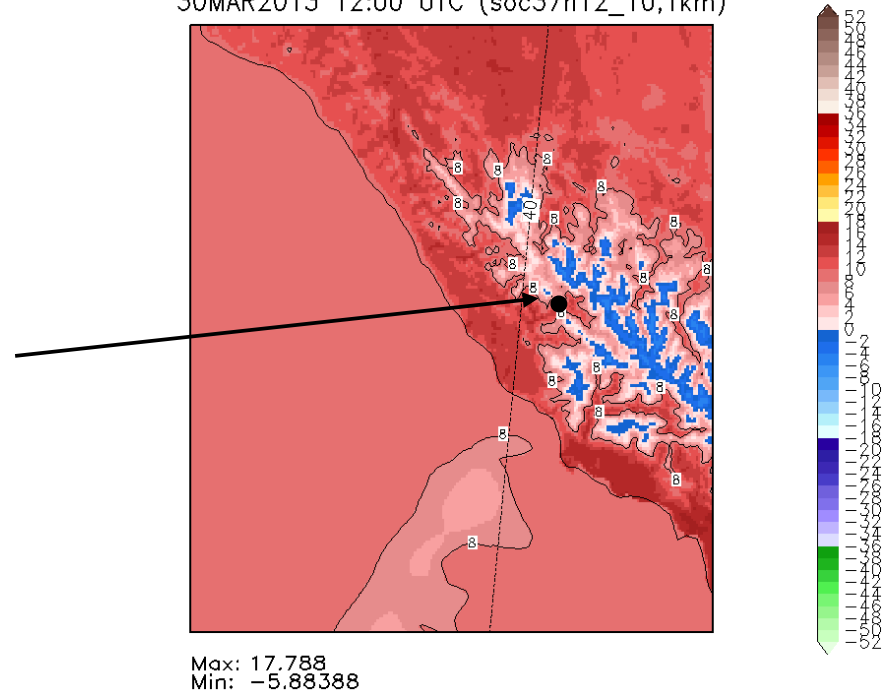
## 2m temperature, Krasnaya Polyana, Jan 2013

Selection: KrasnayaPolyana using 1 stations  
 Period: 201301  
 T2m Hours: {00,12}



## HARMONIE – 1.0km

HARMONIE 30MAR2013 00 UTC. Temperature-2m [°C]  
 30MAR2013 12:00 UTC (soc37h12\_10,1km)



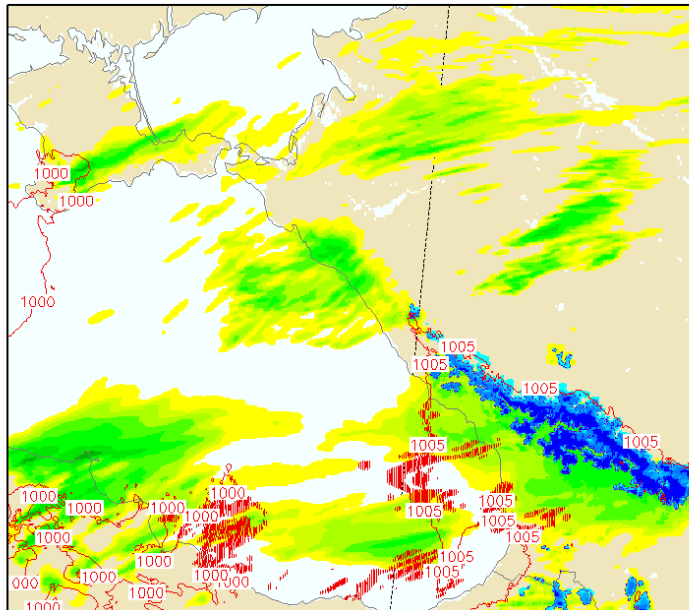


# Comparison experiments (3/3)

*Problems of high resolution?*

## HARMONIE – 1.5km

HARMONIE 12MAR2013 00 UTC. Precipitation [mm 3h<sup>-1</sup>]  
12MAR2013 15:00 UTC (soc37h12\_15,1.5km)

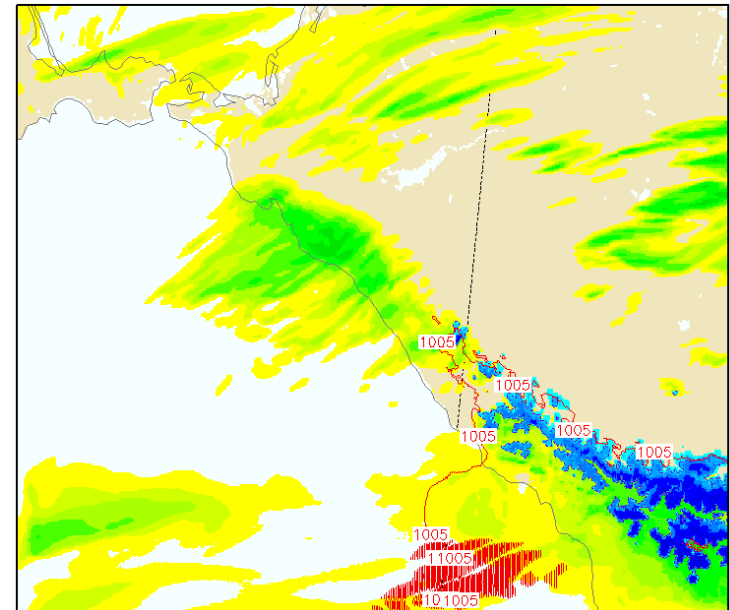


Rain\_max:  
24.5195  
Snow\_max:  
6.2373  
Graupel\_ma:  
10.8545



## HARMONIE – 1.0km

HARMONIE 12MAR2013 00 UTC. Precipitation [mm 3h<sup>-1</sup>]  
12MAR2013 15:00 UTC (soc37h12\_10,1km)



Rain\_max:  
13.8184  
Snow\_max:  
4.93848  
Graupel\_m:  
13.2305



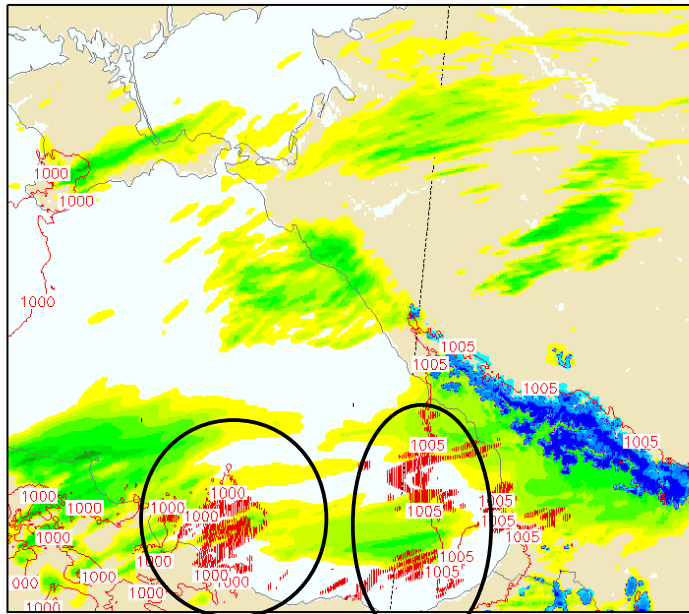


# Comparison experiments (3/3)

*Problems of high resolution?*

## HARMONIE – 1.5km

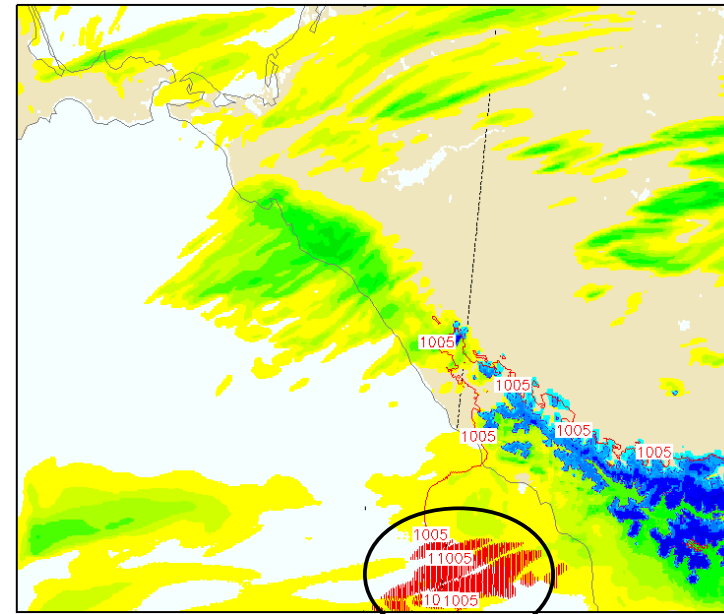
HARMONIE 12MAR2013 00 UTC. Precipitation [mm 3h<sup>-1</sup>]  
12MAR2013 15:00 UTC (soc37h12\_15,1.5km)



Rain\_max:  
24.5195  
Snow\_max:  
6.2373  
Graupel\_ma:  
10.8545

## HARMONIE – 1.0km

HARMONIE 12MAR2013 00 UTC. Precipitation [mm 3h<sup>-1</sup>]  
12MAR2013 15:00 UTC (soc37h12\_10,1km)



Rain\_max:  
13.8184  
Snow\_max:  
4.93848  
Graupel\_m:  
13.2305

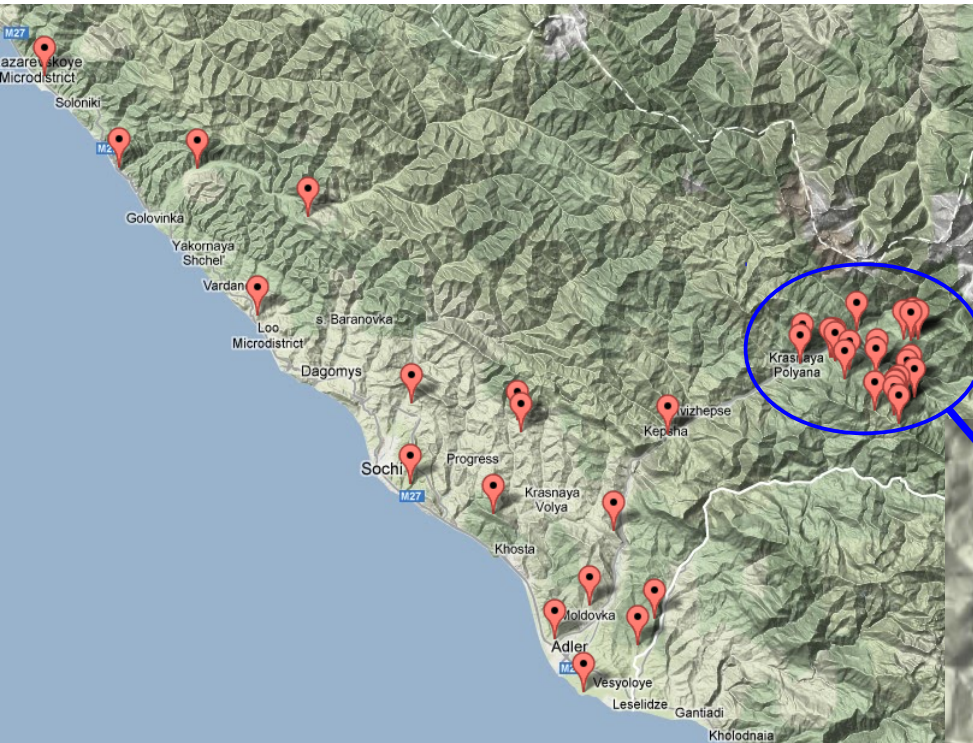
**Noise in pressure fields! 5 – 7 crashes during 3 months**

**Time step: 40s → 30s**

**Time step: 30s → 20s → 15s**

**Reduced time step helped model to survive, but did not reduce the noise**

# Verification to be done...



**42 additional observation stations  
around Sochi region**



**24 additional observation stations  
In the mountain cluster**





# Summary

- Several HARMONIE experiments were setup over Sochi region
- 3 month running period (Jan – Mar 2013)
- HARMONIE – 2.5km was superior over Hirlam and IFS in Sochi region.
- Impact of SRTM orography data set was neutral.
- Overall, HARMONIE 1km and 1.5km showed slight improvement over 2.5km. Local improvements significant!
- HARMONIE 1km and 1.5km suffered (yet) unresolved instability problems.



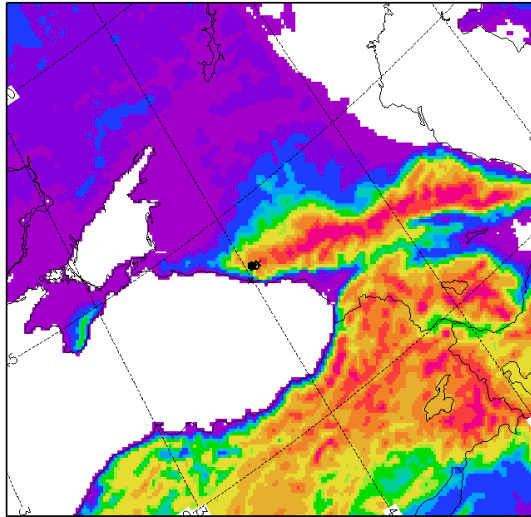
**THANK YOU**





## OPERATIONAL HIRLAM 7.5km

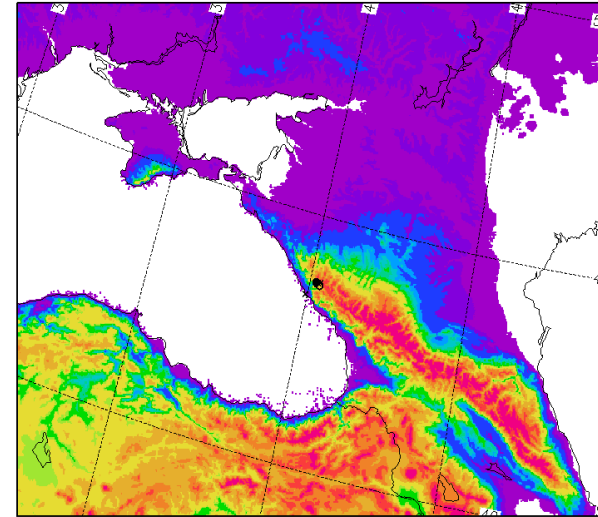
HIRLAM 04APR2013 00 UTC. Orographic height [m]  
 04APR2013 06:00 UTC (v74,7.5km)



Max: 3578.87  
 Min: -129.994

## EXPERIMENTAL HARMONIE 2.5km

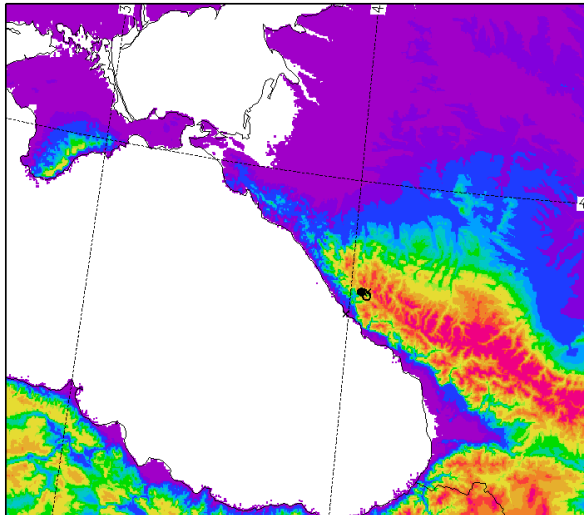
HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
 31DEC2012 18:00 UTC (soc37h12,2.5km)



Max: 4871.41  
 Min: -35.0667

## EXPERIMENTAL HARMONIE 1.5km

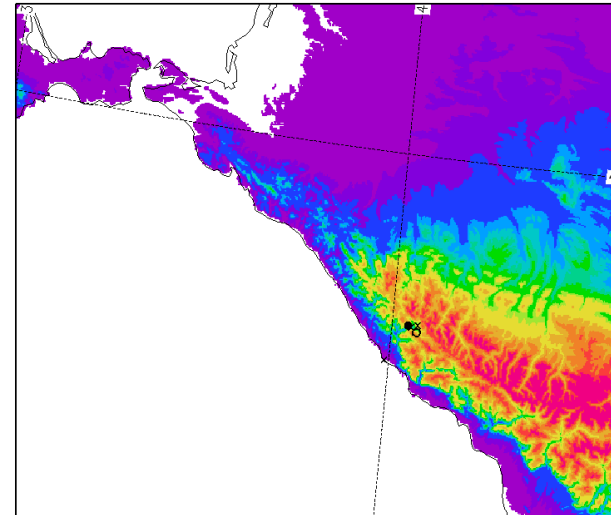
HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
 31DEC2012 18:00 UTC (soc37h12\_15,1.5km)



Max: 5159.22  
 Min: -35.4783

## EXPERIMENTAL HARMONIE 1.0km

HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
 31DEC2012 18:00 UTC (soc37h12\_10,1km)



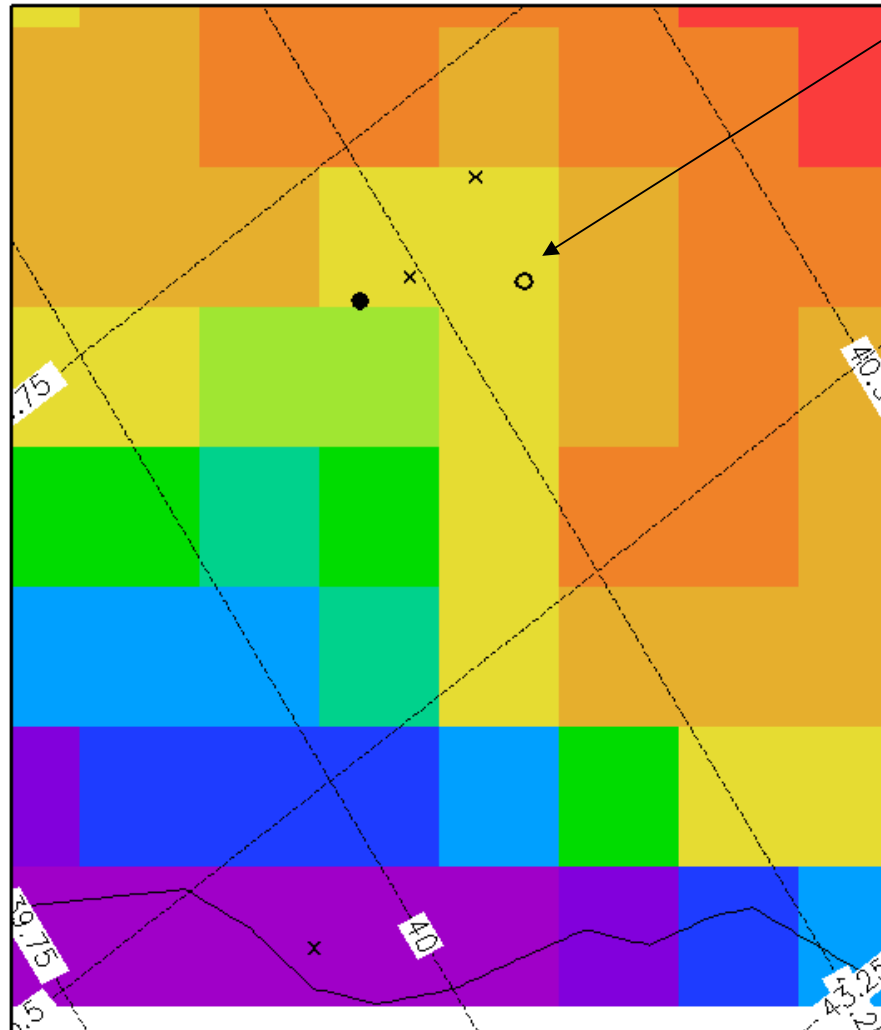
Max: 5357.32  
 Min: -19.5967



HIRLAM 04APR2013 00 UTC. Orographic height [m]  
04APR2013 06:00 UTC (V74,7.5km)

**MetGram**

**7.5km**



Elevations

Ski stadium: ~1400m

Combined: ~650m

Krasnaya Polyana: ~560m

Max: 2358.9  
Min: 0.48522

Skiing: 1386m

Combined: 1339m

KrasnayaPolyana: 1339m

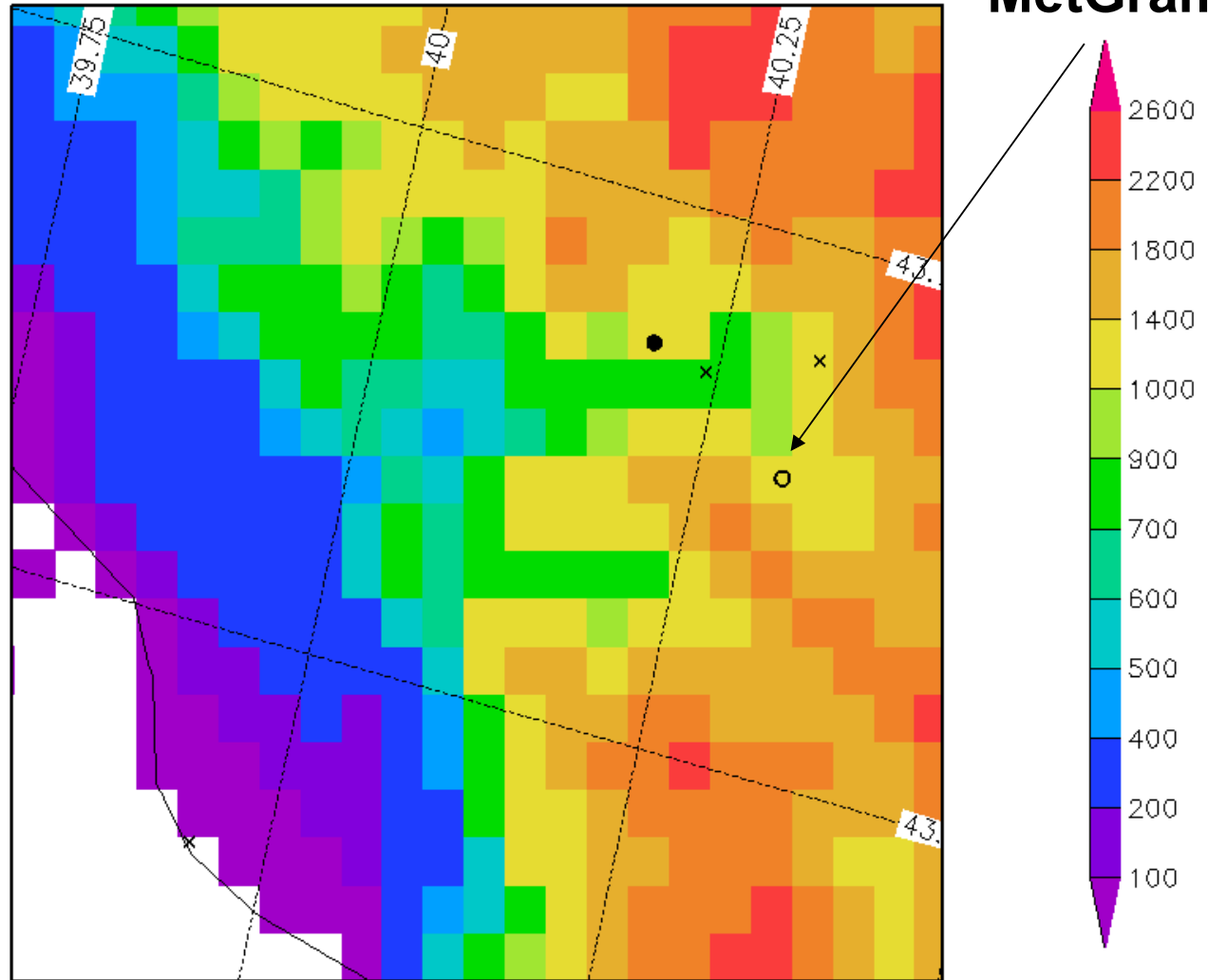




HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
 31DEC2012 18:00 UTC (soc37h12,2.5km)

**MetGram**

**2.5km**



Elevations

Ski stadium: ~1400m

Combined: ~650m

Krasnaya Polyana: ~560m

Max: 2568.5  
 Min: -19.2884

Skiing: 1208m

Combined: 809m

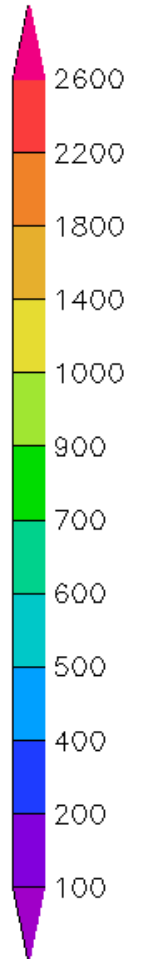
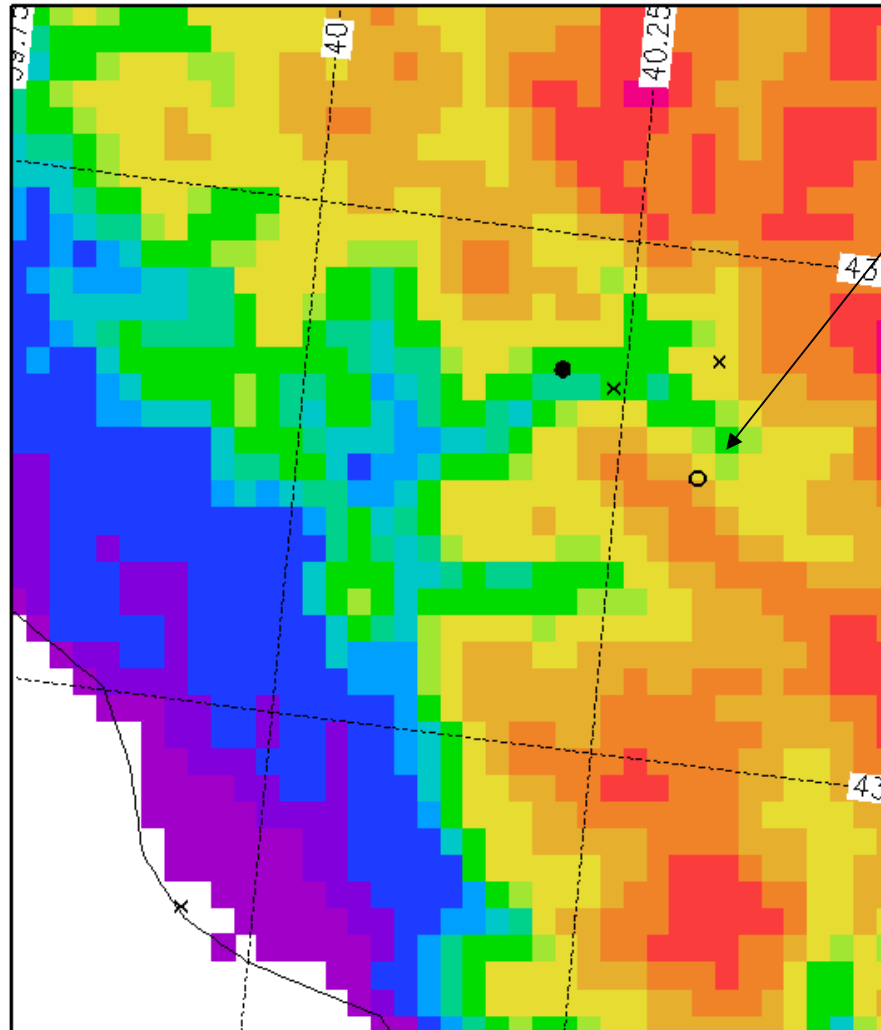
KrasnayaPolyana: 1009m



HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
31DEC2012 18:00 UTC (soc37h12\_15,1.5km)

**MetGram**

**1.5km**



Elevations

Ski stadium: ~1400m

Combined: ~650m

Krasnaya Polyana: ~560m

Max: 2728.11  
Min: -9.94847

Skiing: 1318m

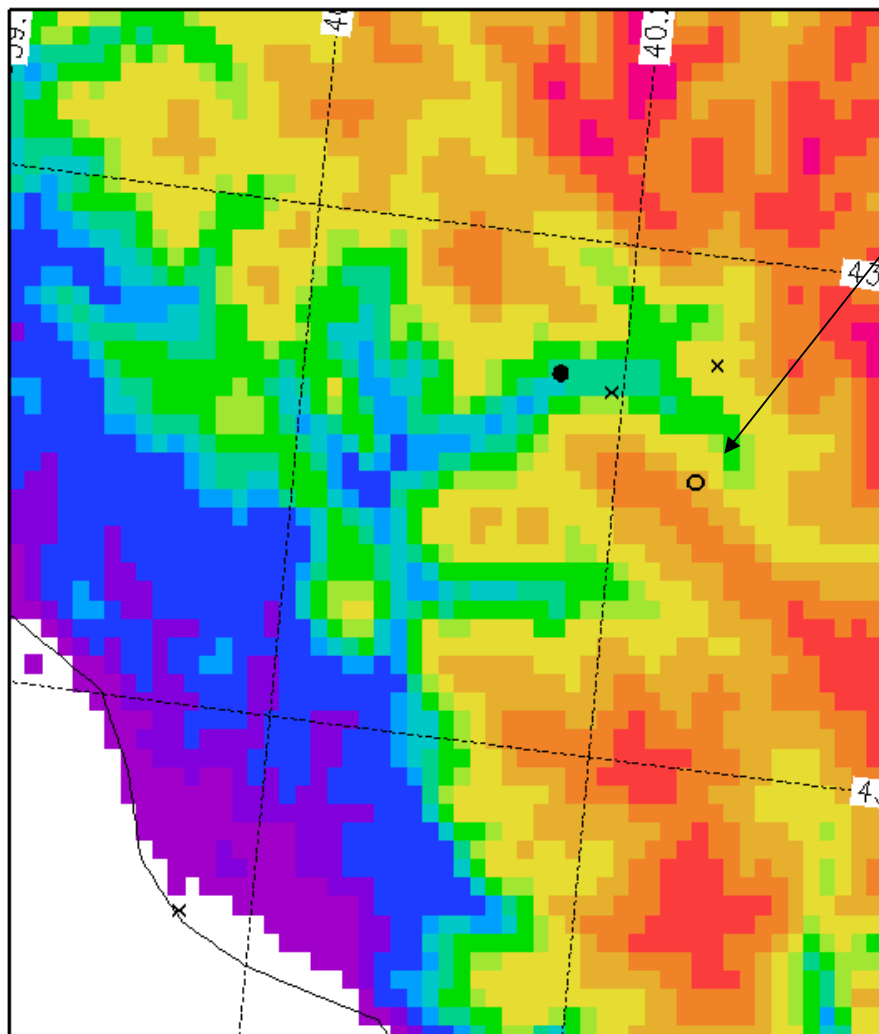
Combined: 722m

KrasnayaPolyana: 776m

HARMONIE 31DEC2012 12 UTC. Orographic height [m]  
 31DEC2012 18:00 UTC (soc37h12\_10,1km)

**MetGram**

**1.0km**



Elevations

Ski stadium: ~1400m

Combined: ~650m

Krasnaya Polyana: ~560m

Max: 2841.85  
 Min: -6.43268

Skiing: 1360m

Combined: 664m

KrasnayaPolyana: 654m