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Canada

Parameterization issues and related modeling challenges at the CMC

Ayrton Zadra
RPN/ECCC

WGNE - 31
Council for Scientific and Industrial Research
South Africa
26 - 29 April 2016

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Contents

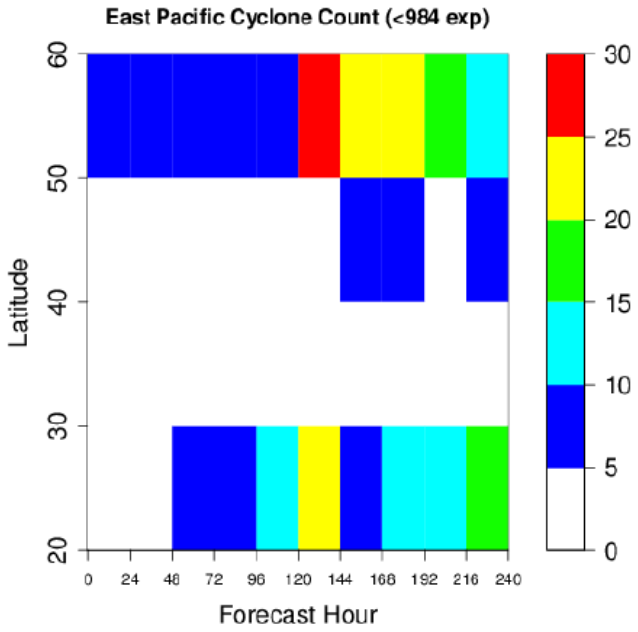
NWP forecast errors from CMC models

1. **Detection**, **verification** and **diagnostics**
   - feedback from forecasters
   - objective tools

2. Related to **physical parametrizations**
   - process issues
   - resolution issues
   - coupling issues

Systematic errors identified by forecasters

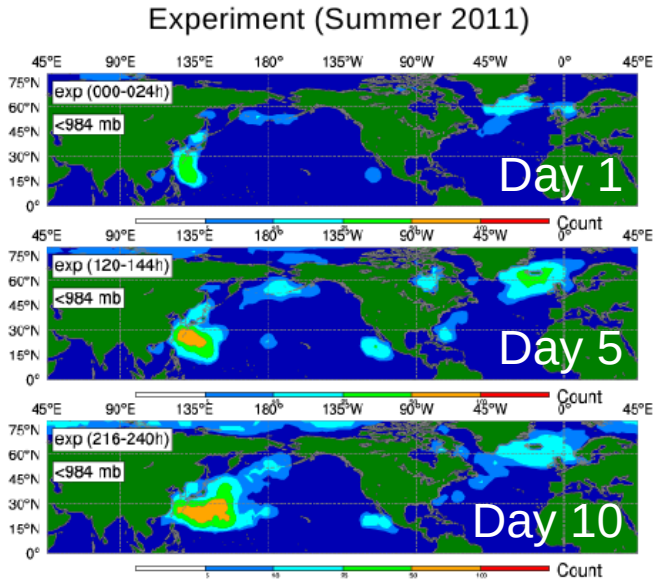
*Mean **cyclonic activity** varies with forecast lead time*



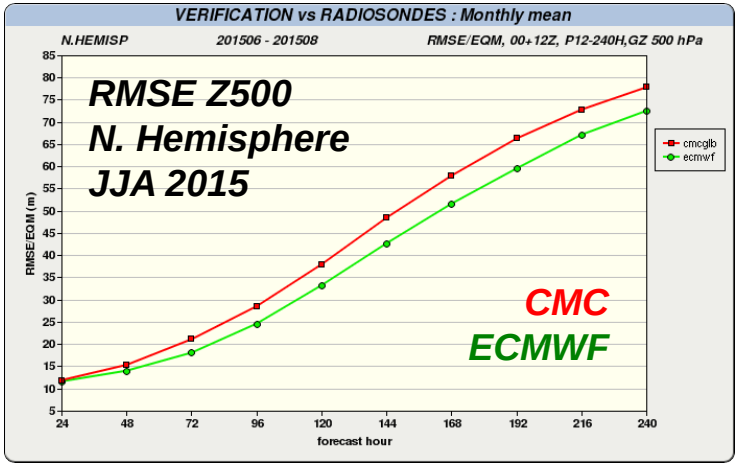
GDPS, JJA 2011, E. Pacific: e
Cyclone count vs lead time

[Material provided by R. McTaggart-Cowan]

Cyclone density map

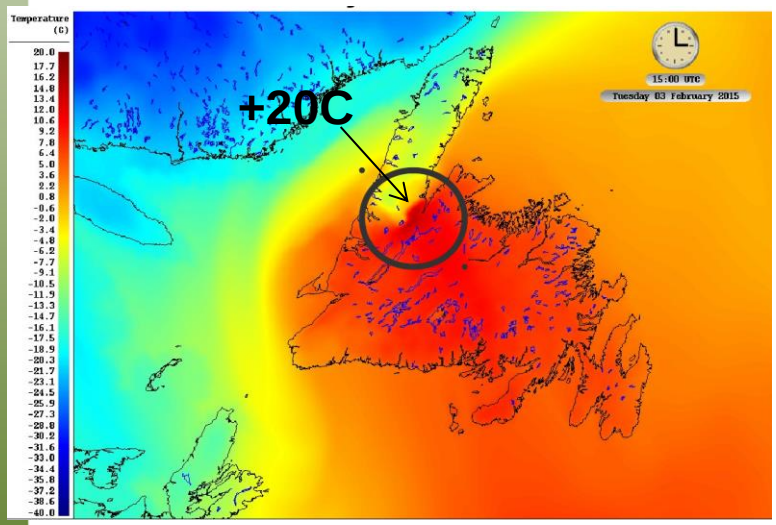


*Probably related to **error growth rate***



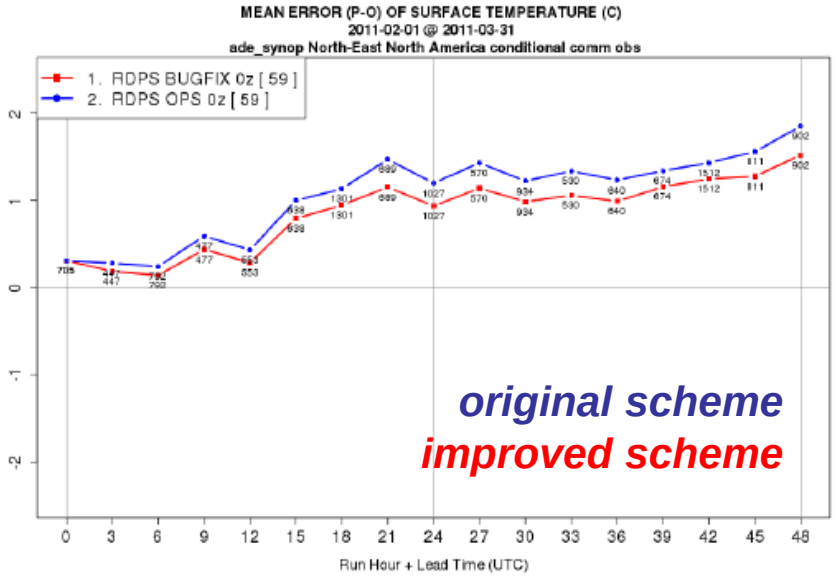
Systematic errors identified by forecasters

Surface temperature errors (warm bias) related to episodes of ***rain over snow***



Rain-over-snow event:
RDPS forecast, 2m-temperature, valid 03-Feb-2015 15UTC

Attributed to limitations in the current ***land-surface scheme***



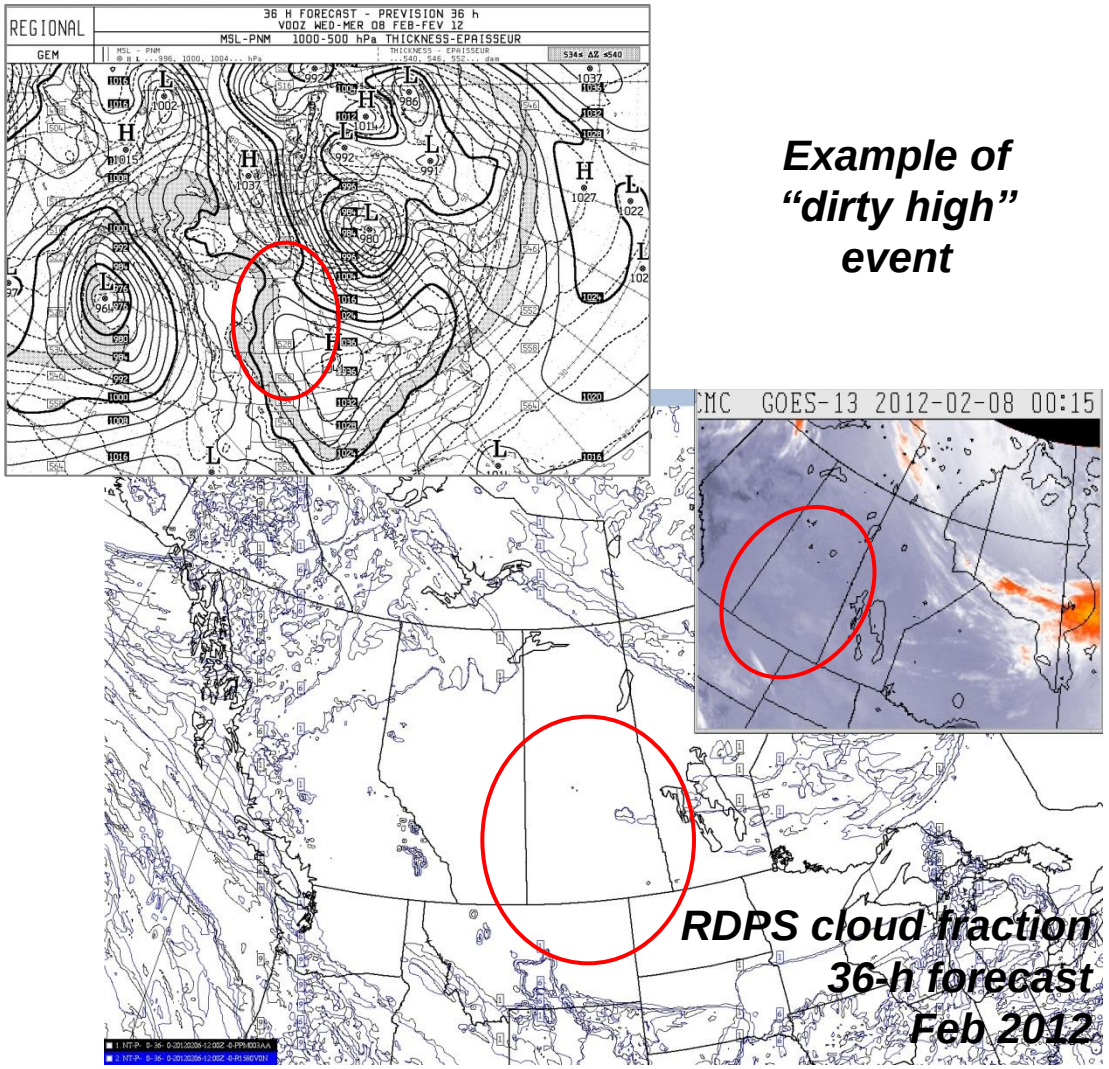
Conditional verification of T2m bias:

- ***Feb 2011, North-east N.America***
- ***cond 1: predicted T2m > 1C***
- ***cond 2: predicted QPF > 1mm/6h***

Systematic errors identified by forecasters

*Poor forecast of thin layer of low-level clouds under ridges (a.k.a. "**dirty highs**")*

Attributed to limitations in microphysics, vertical resolution and initialization.



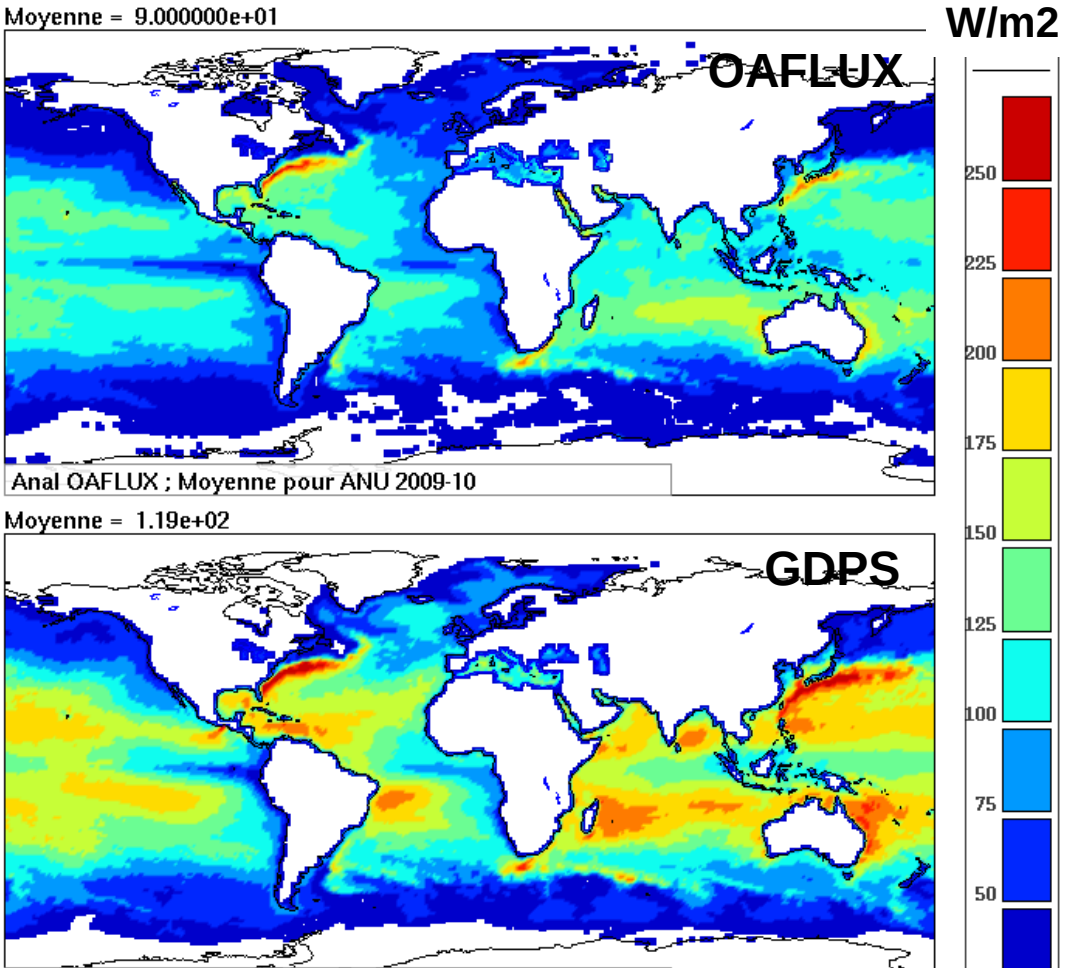
Example of "dirty high" event

RDPS cloud fraction 36-h forecast Feb 2012

Systematic errors based on objective verification tools

*Excessive **moisture fluxes** (LHF) over the oceans*

*One of the variables evaluated in **hydrology-energy budget** of ensembles of 1-year forecasts*



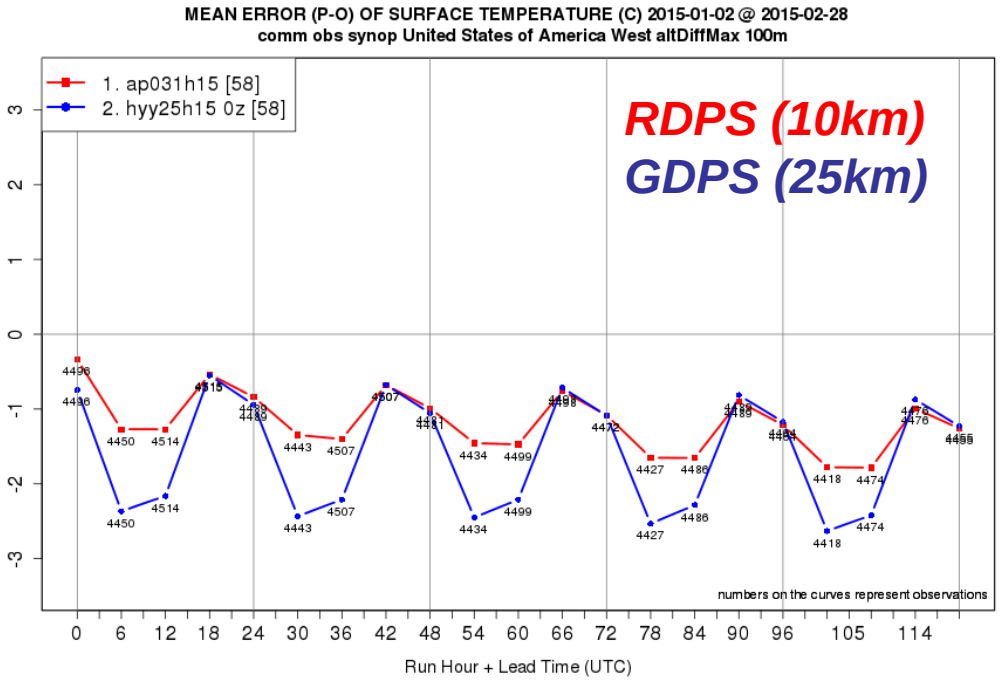
2009-2010 average of LHF

Analysis products provided by the WHOI OAFlux project (http://oaflux.whoi.edu) funded by the NOAA Climate Observations and Monitoring program

Systematic errors identified by forecasters

*2m-temperature errors **(cold bias) under stable conditions***

Long standing challenge, somewhat reduced at higher resolution (horizontal and vertical)



2m-temperature bias versus lead time: West USA, Jan 2015

Issues related to physical parameterizations

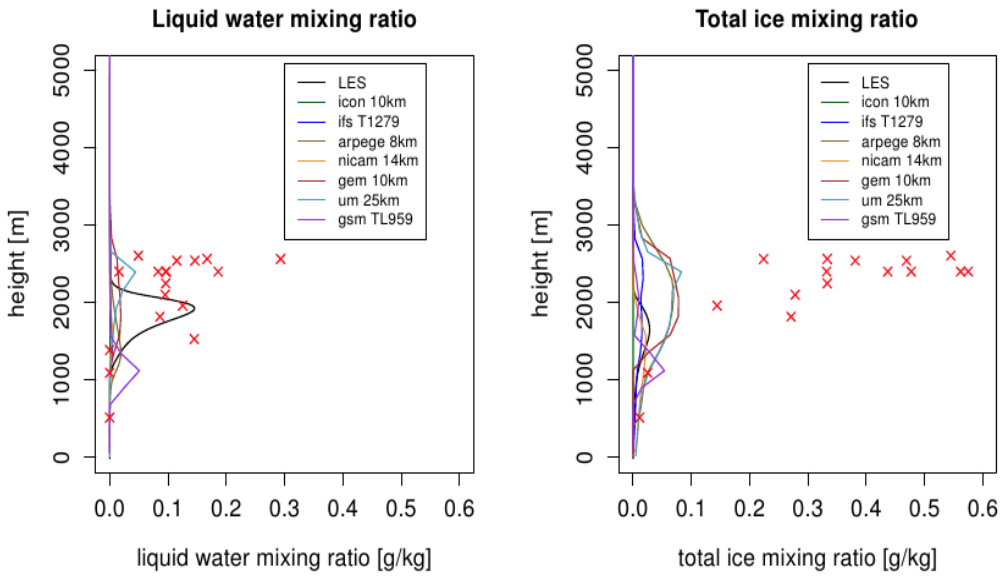
Some **processes** currently missing (or inactive or being explored) in the physics of some NWP systems at CMC:

- **surface**
  - *multi-layer multi-budget scheme*
  - *effect of salinity on moisture fluxes*
  - *effect of gustiness and precipitation on turbulent fluxes*
- **PBL**
  - *non-local terms from PBL clouds*
- **microphysics**
  - *cloud fraction in double-moment scheme*
- **convection**
  - *momentum transport*
  - *stochasticity*

Issues related to physical parameterizations

Issues related to **cloud - aerosol – radiation** processes:

- *partition between liquid/ice water for mixed-phase clouds (more obs data needed)*
- *account for droplet size distribution in connection with radiation*
- *representation of cloud-aerosol interactions*



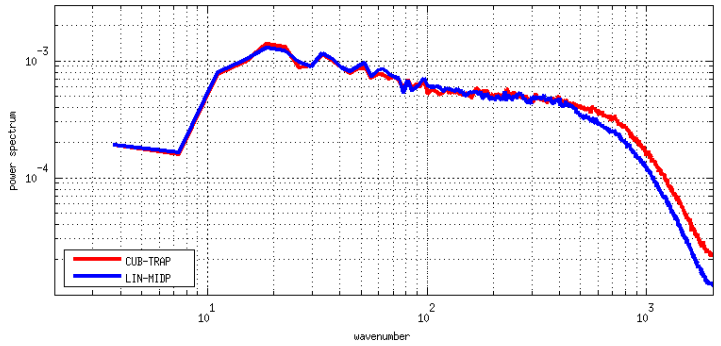
From the "Grey Zone" cold air outbreak global model intercomparison project: Results for the reference configurations of the participating models in the "cumulus" case. Also observations from the aircraft flight: each red cross indicates the mean over multiple measurements taken at a particular height along a leg of the flight.

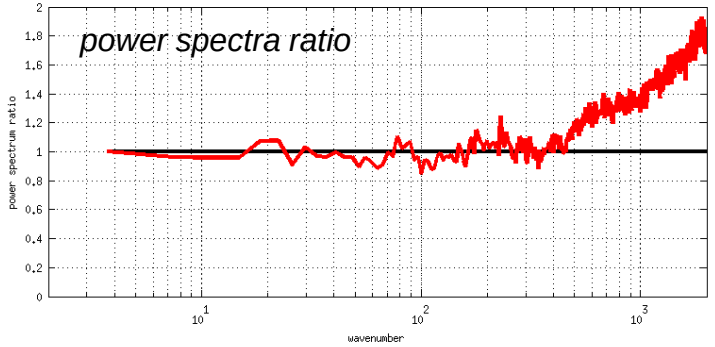
Issues related to physical parameterizations

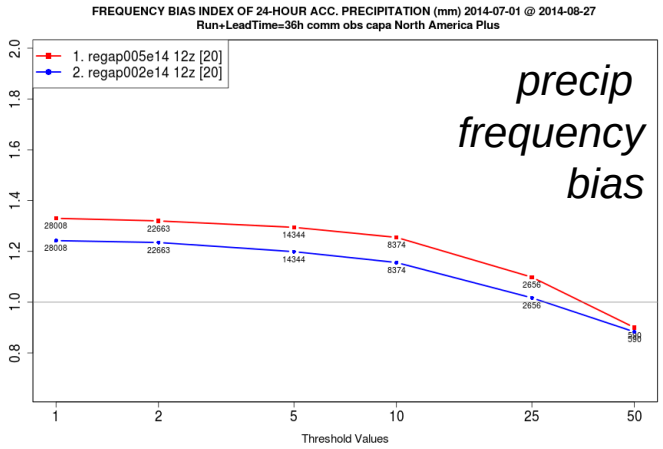
Coupling between dynamics and physics:

Improvements to the dynamics have required adjustments to the physics, (e.g. due to more accurate vertical motion)

W power spectra at t = 48h





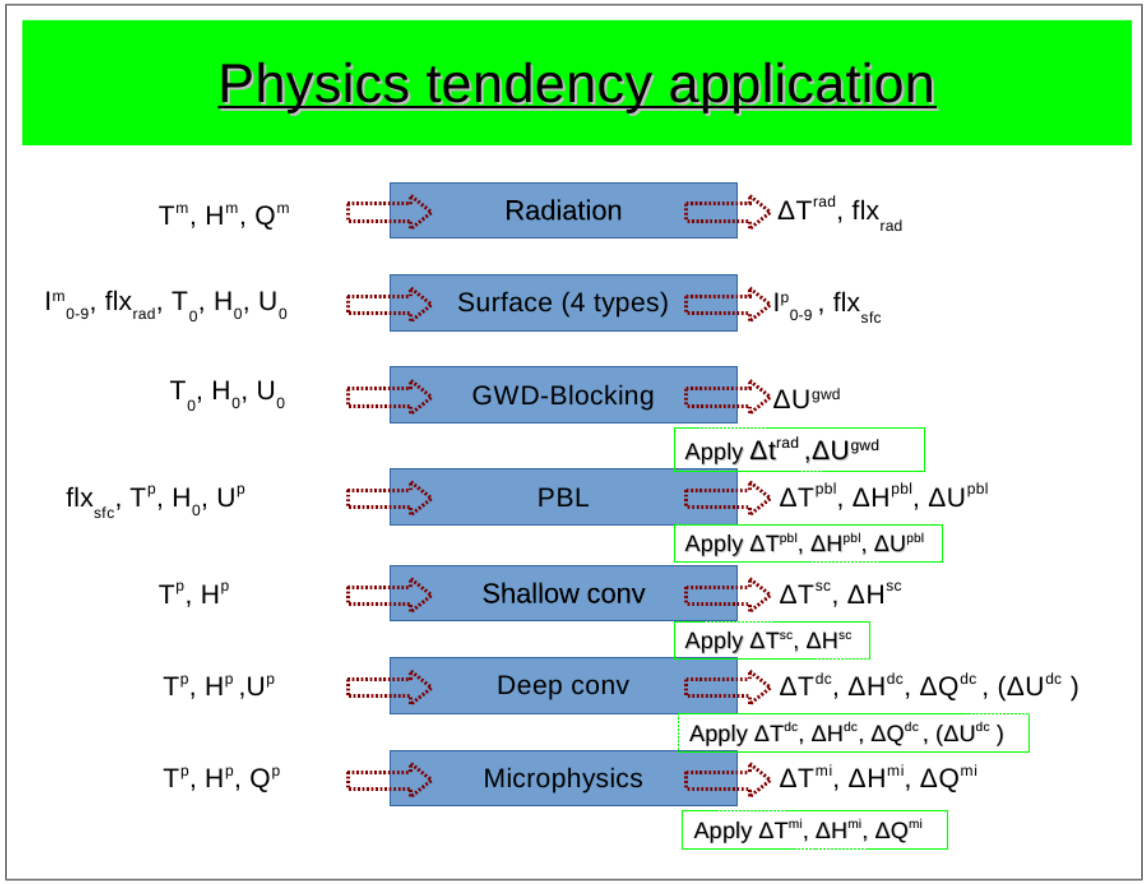


RDPS power spectrum of low-level vertical velocity (top) and QPF bias (left) using cubic-trapezoidal (red) or linear-midpoint (blue) interpolations in semi-lag scheme.

Issues related to physical parameterizations

Uncertainty in the **sequencing** of and **interaction** between physical parameterizations

[Material provided by P. Vaillanciourt]



Issues related to physical parameterizations

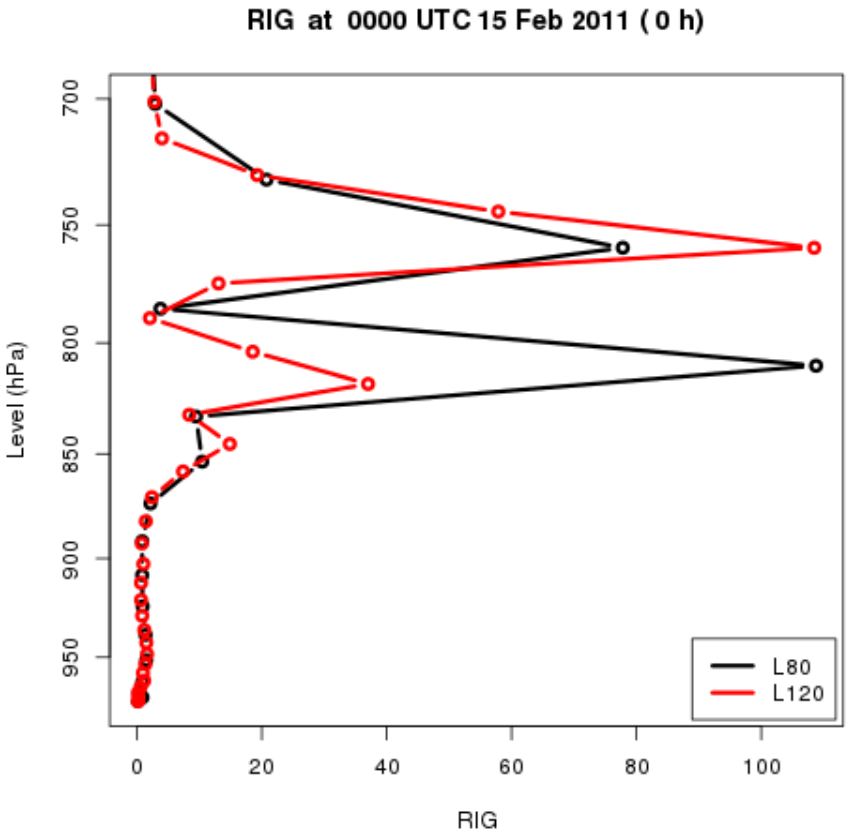
Sensitivity to vertical resolution, in particular in the boundary layer:

- *Ri-dependent* ***stability functions***

- mixing length

- orographic blocking

- turbulent fluxes (e.g. when dynamics better resolves some near-surface phenomena)



Profiles of gradient Richardson number obtained from equal input but different vertical resolutions.

Issues related to physical parameterizations

Sensitivity to vertical resolution, in particular in the boundary layer:

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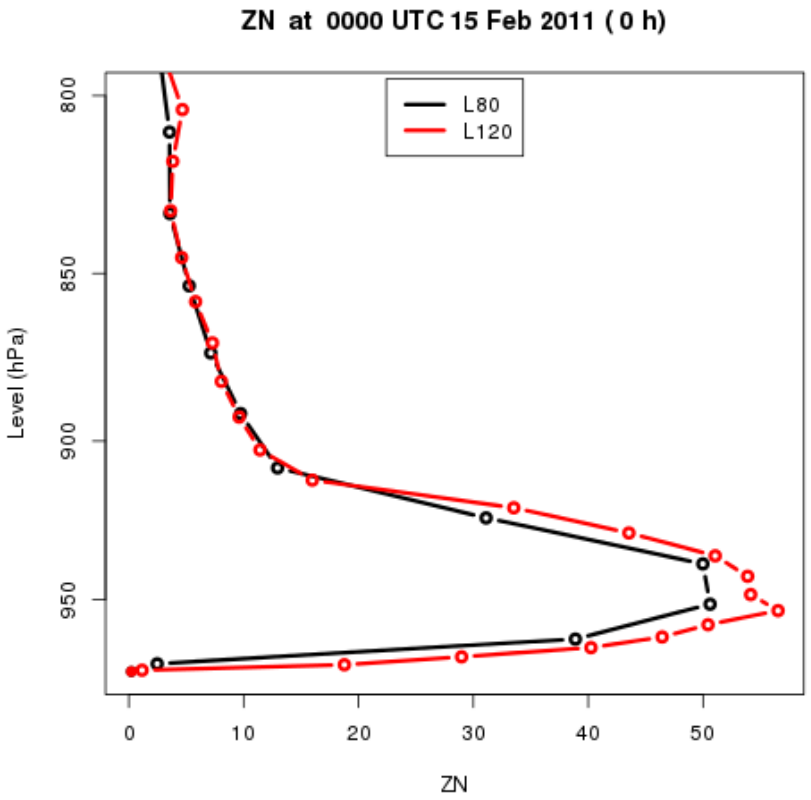
- ***mixing length***

- *orographic blocking*

- *turbulent fluxes (e.g. when dynamics better resolves some near-surface phenomena)*



Profiles of mixing length (Bougeault-Lacarrere) obtained from equal input but different vertical resolutions.

Issues related to physical parameterizations

Sensitivity to vertical resolution, in particular in the boundary layer:

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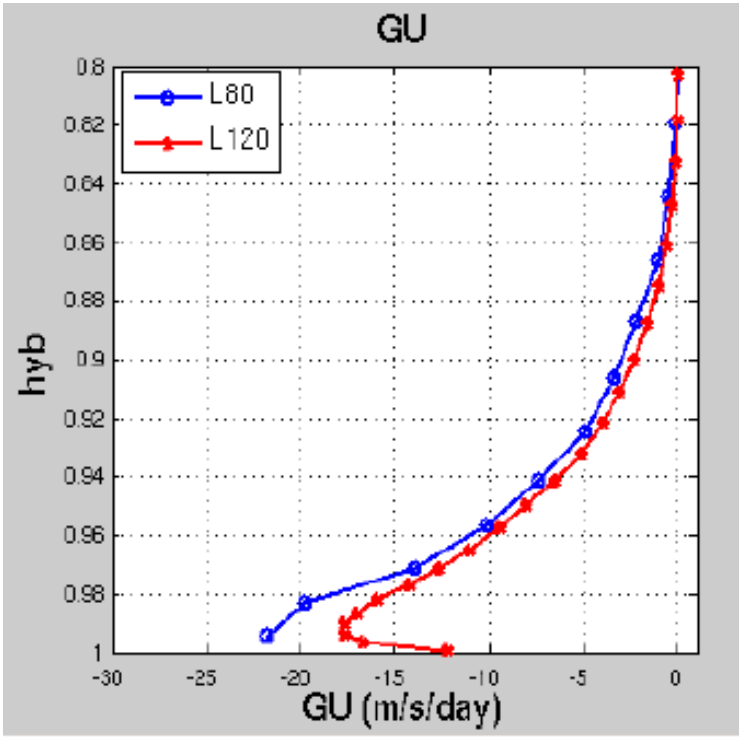
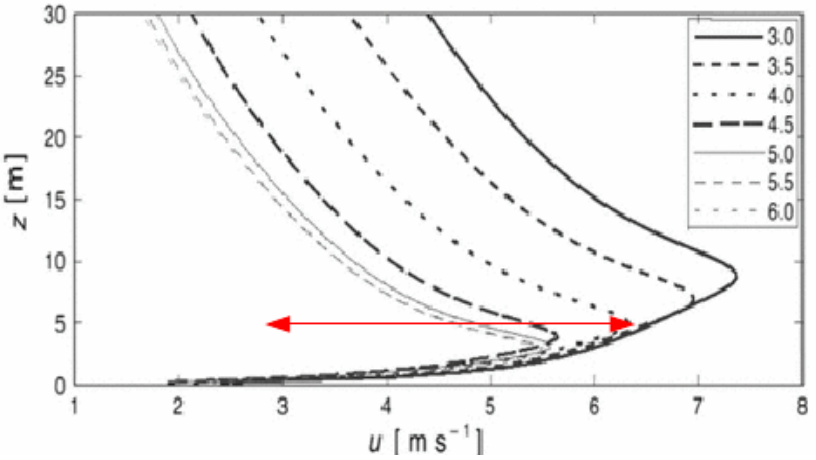


Average profiles (12h, southern Rockies, winter case) of orographic blocking tendency, using different vertical resolutions.

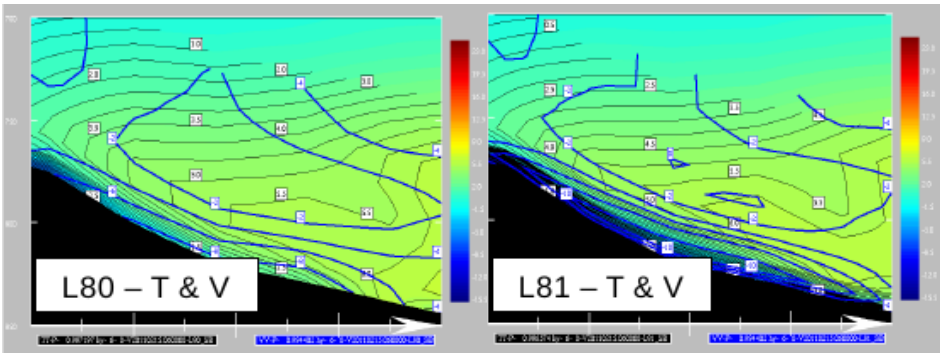
Issues related to physical parameterizations

Sensitivity to vertical resolution, in particular in the boundary layer:

- *Ri-dependent stability functions*
- *mixing length*
- *orographic blocking*
- ***turbulent fluxes*** *(e.g. when dynamics better resolves some near-surface phenomena)*



Drainage (katabatic) flow from Grisogono and Alexen (2012) LES study for different slopes.



Cross-sections of temperature and wind for drainage flow simulation, using different vertical grids.

[Material provided by R. McTaggart-Cowan]

Summary

Lessons learned from

- *close collaboration with forecasters*
- *sharing experience (successes and failures) with other groups/centres*
- *participation in international inter-comparison projects*
- *testing model outside its “mandate forecast range”*

To address **systematic errors**, we also need

- *more observational data and/or better use of existing data*
- *improved verification and diagnostic tools*
- *continued emphasis on inter-comparison projects and collaborations*