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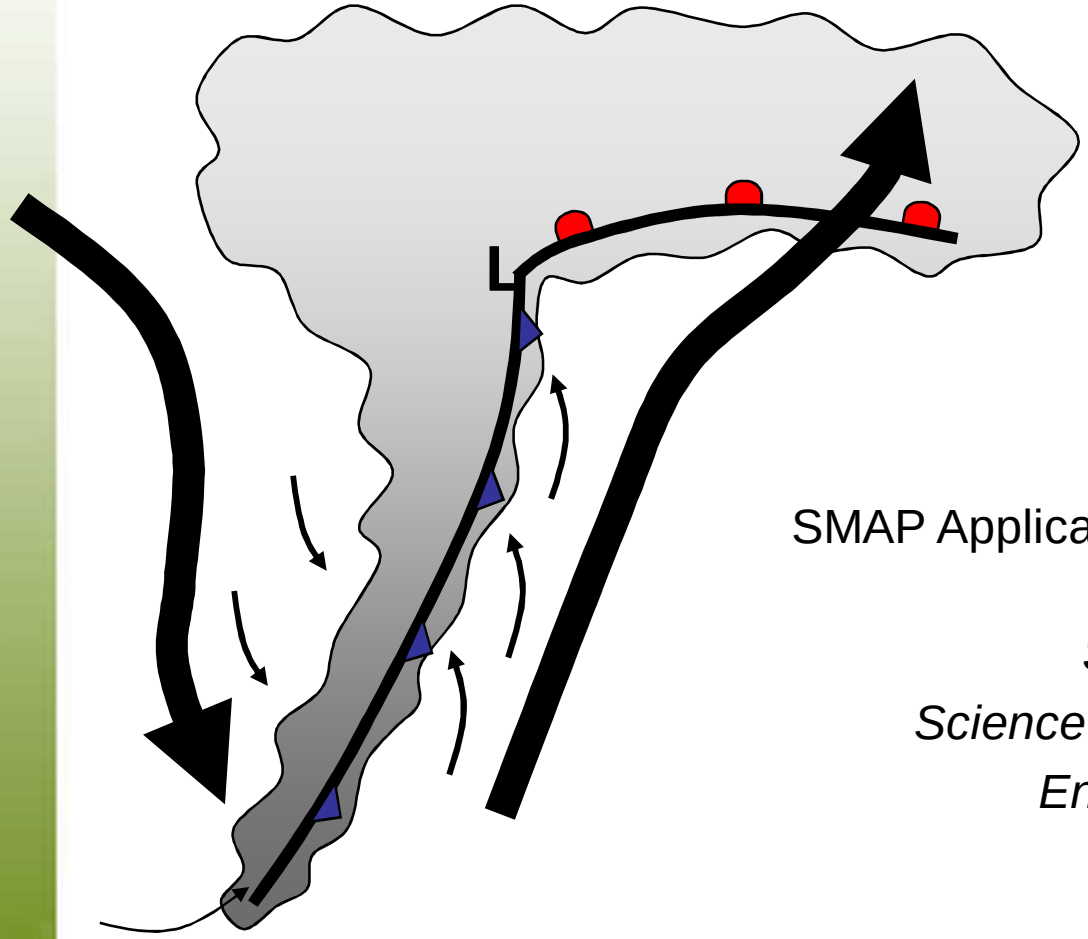
Soil Moisture and Numerical Weather Prediction



SMAP Applications Workshop, Silver Spring, September 2009

Stephane Belair

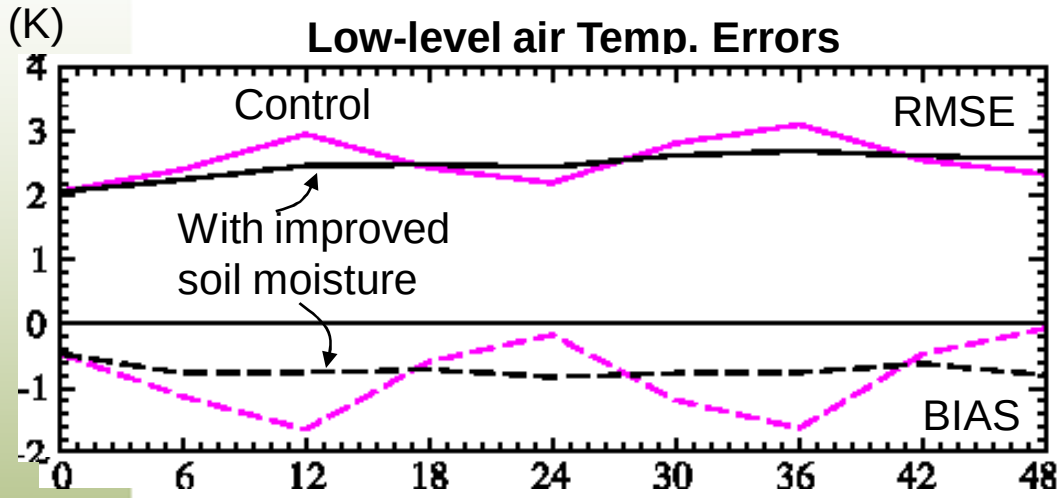
Science and Technology Branch,

Environment Canada

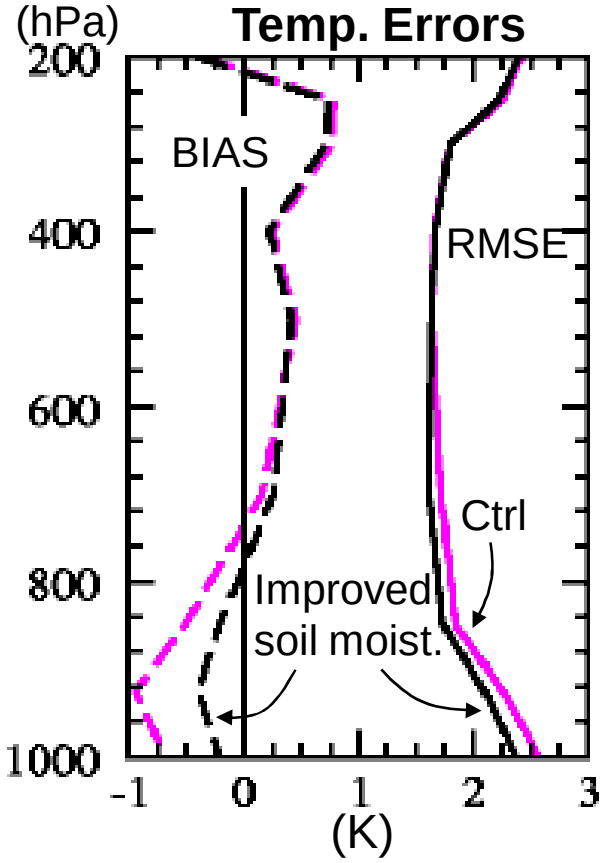
Environnement Canada Environment Canada

MOTIVATION for BETTER SOIL MOISTURE in NWP MODELS

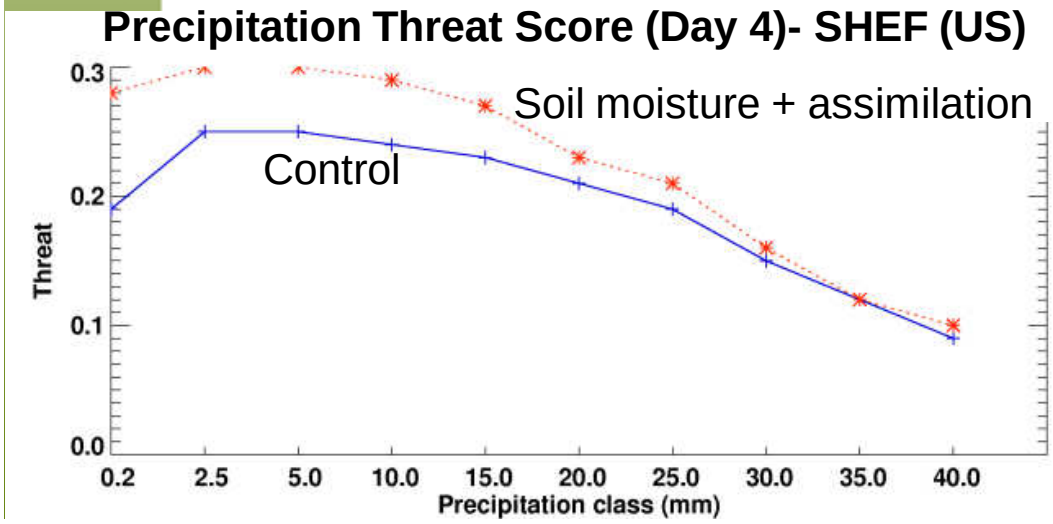
1 NEAR-SURFACE AIR CONDITIONS



2 BOUNDARY-LAYER and MIXING



3 CLOUDS and PRECIPITATION

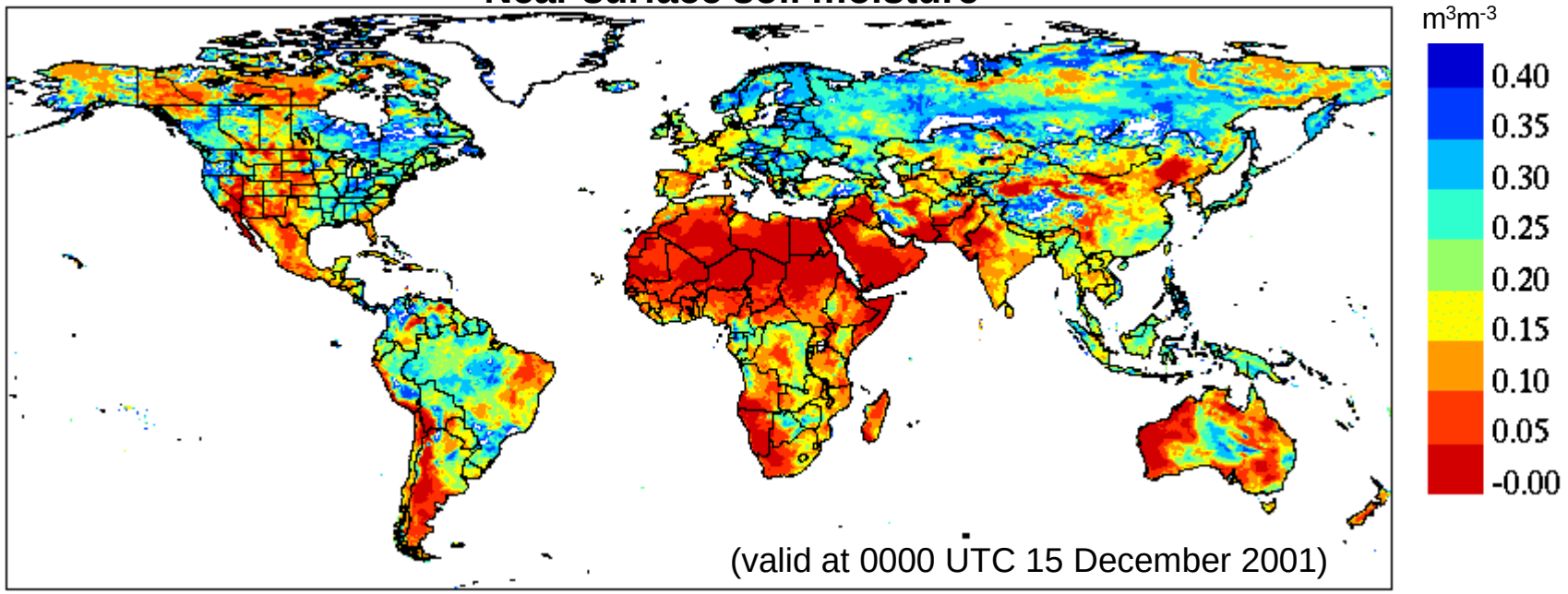


1 and 2: Implementation of short-range regional system in 2001. 48 cases (summertime)

3. Implementation of global medium-range in 2006. 116 cases (summertime)

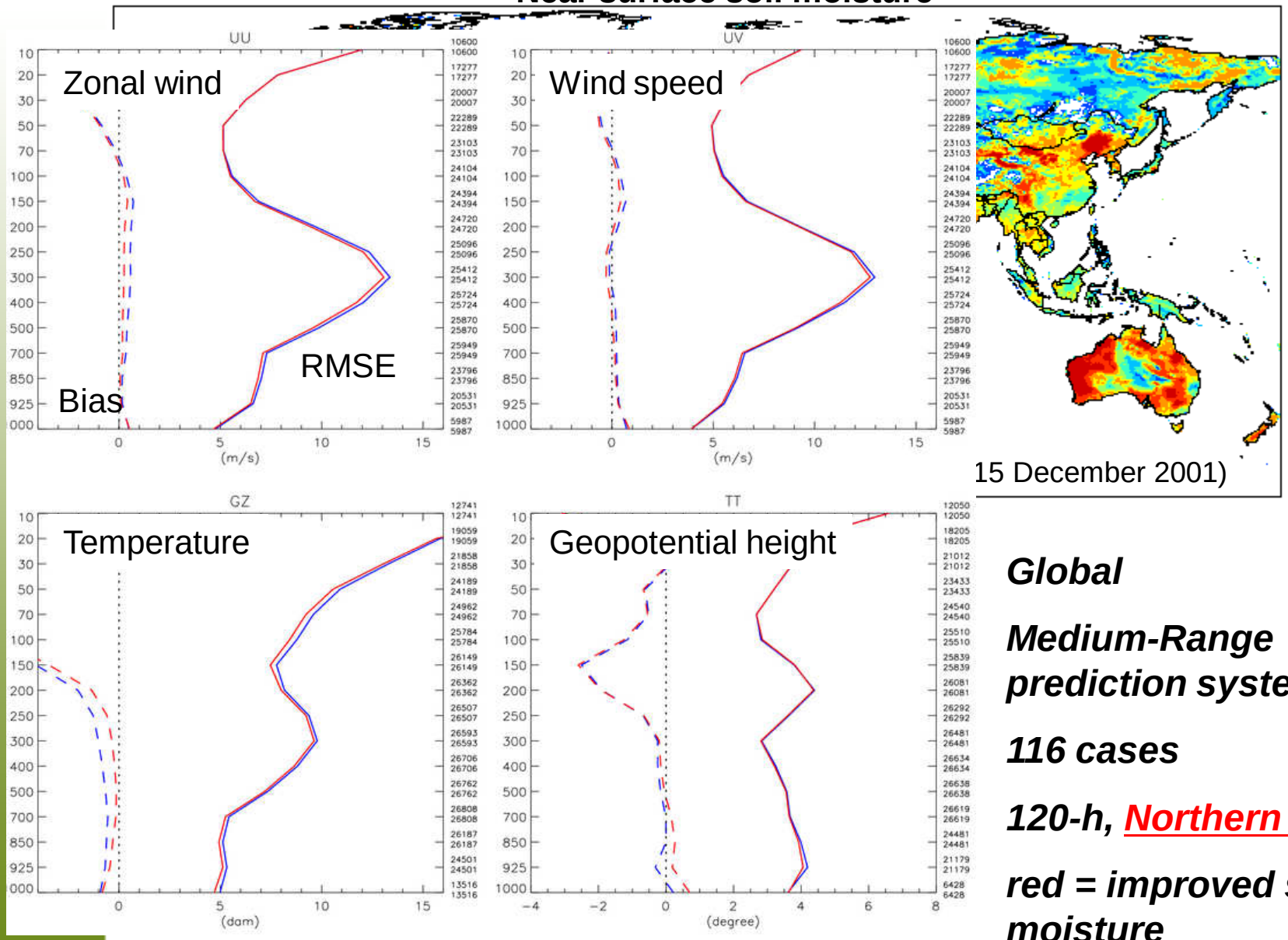
POSSIBLE IMPROVEMENT at MEDIUM-RANGE (GLOBAL MODEL)

Near surface soil moisture



POSSIBLE IMPROVEMENT at MEDIUM-RANGE (GLOBAL MODEL)

Near surface soil moisture



Global

Medium-Range prediction system

116 cases

120-h, Northern Hem.

red = improved soil moisture

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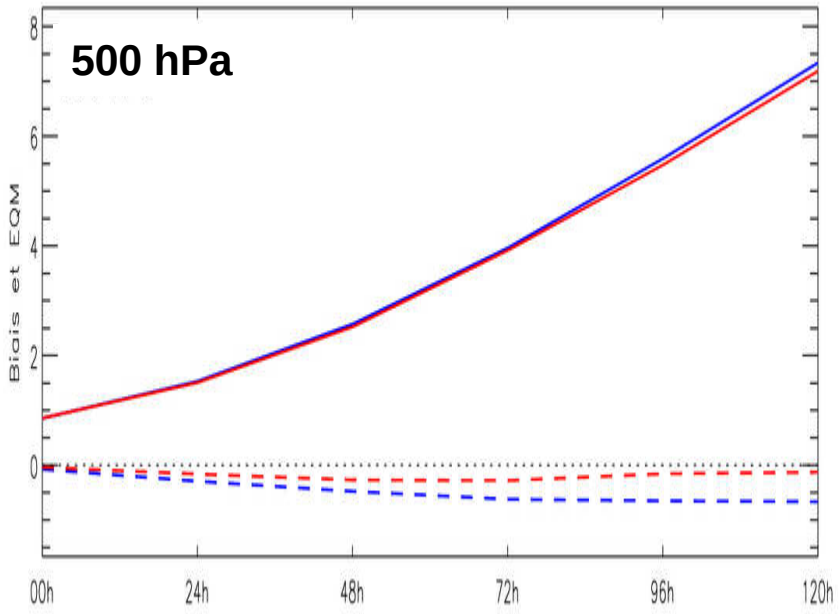
POSSIBLE IMPROVEMENT at MEDIUM-RANGE (GLOBAL MODEL)

RMSE, Geopotential Height

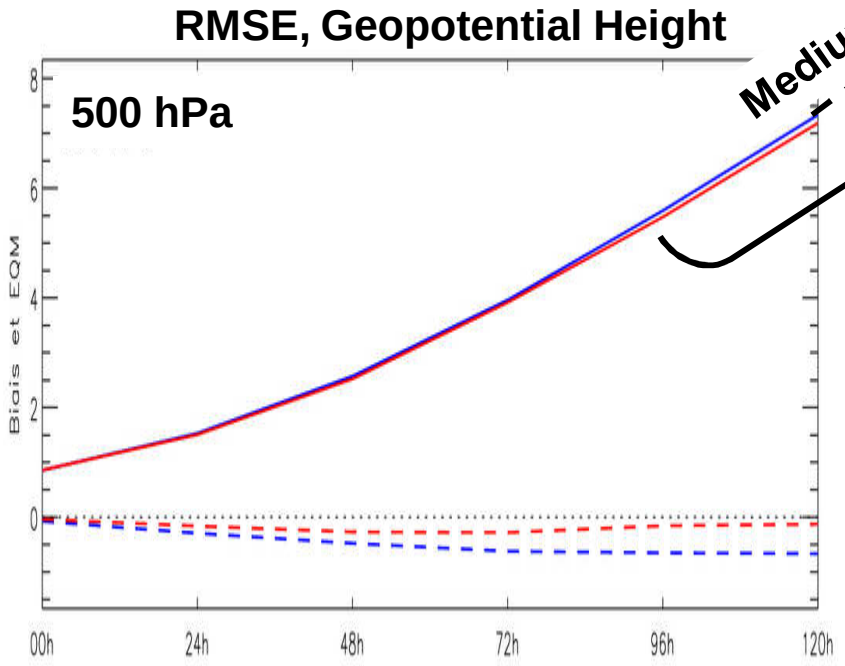


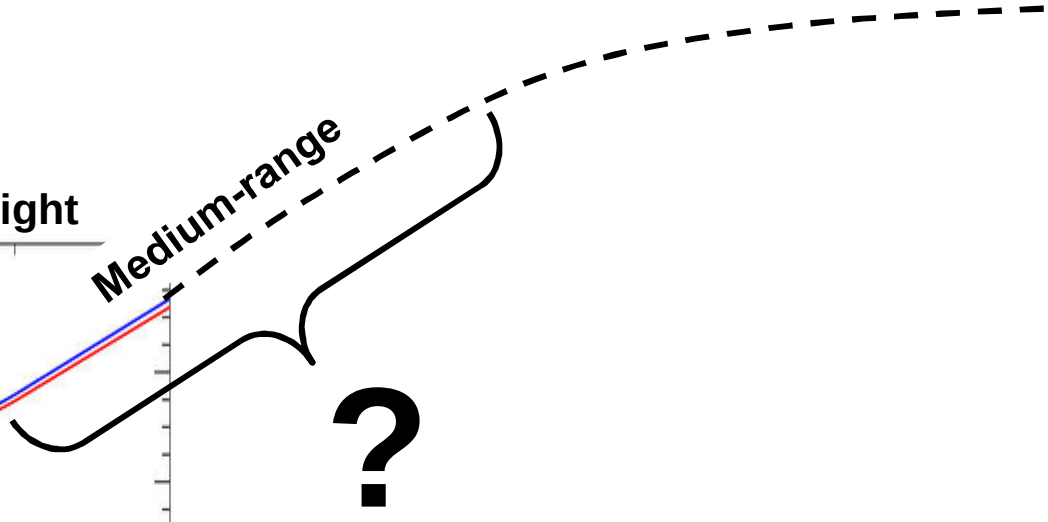
Global, Medium-Range prediction system

116 cases, Northern Hemisphere

red = improved soil moisture

POSSIBLE IMPROVEMENT at MEDIUM-RANGE (GLOBAL MODEL)



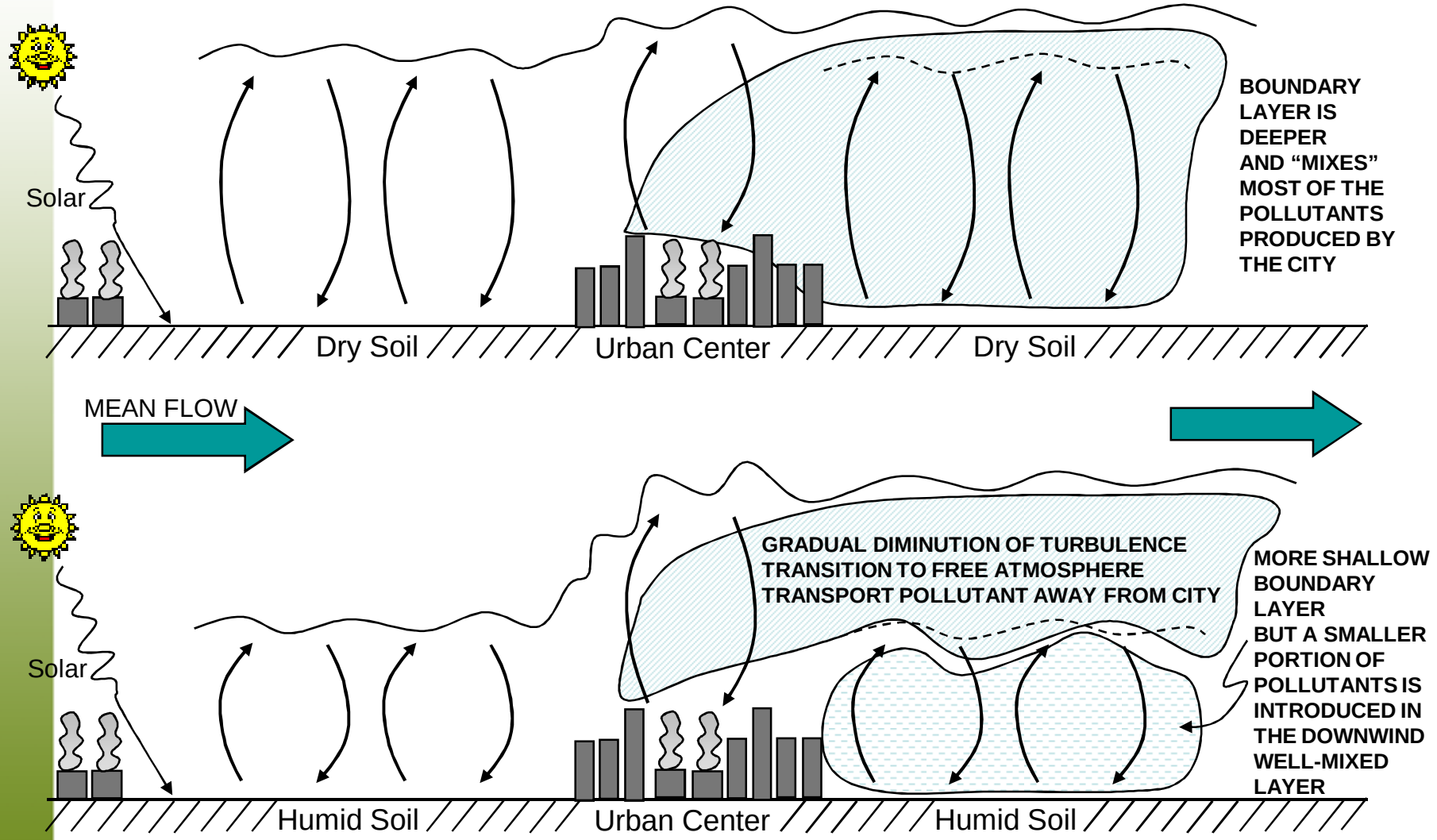


Global, Medium-Range prediction system

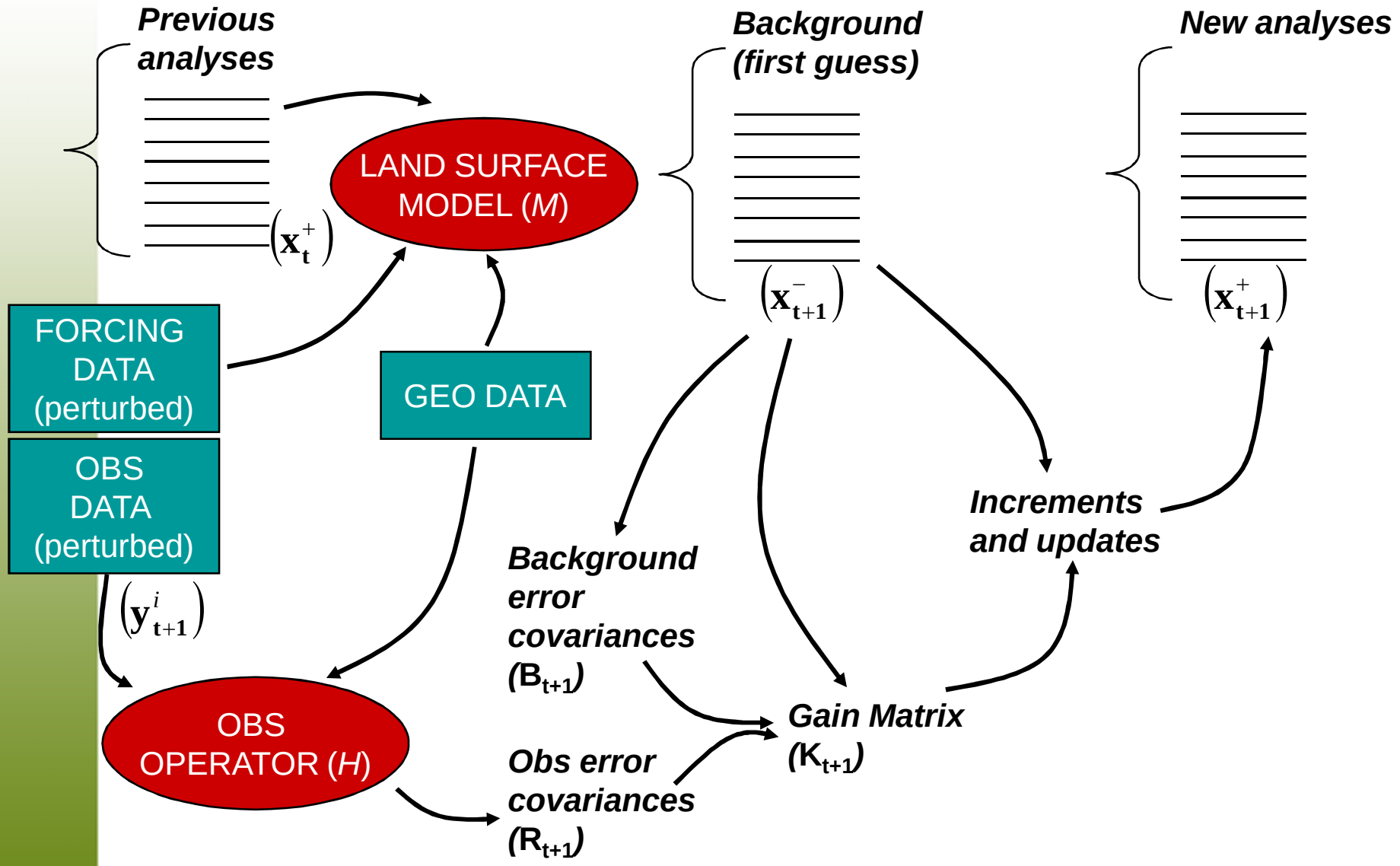
116 cases, Northern Hemisphere

red = improved soil moisture

OTHER ASPECTS BECOMING MORE IMPORTANT
SOIL MOISTURE and AIR QUALITY / DISPERSION



SMAP DATA in the ENSEMBLE KALMAN FILTER of the CANADIAN LAND DATA ASSIMILATION SYSTEM (CaLDAS)



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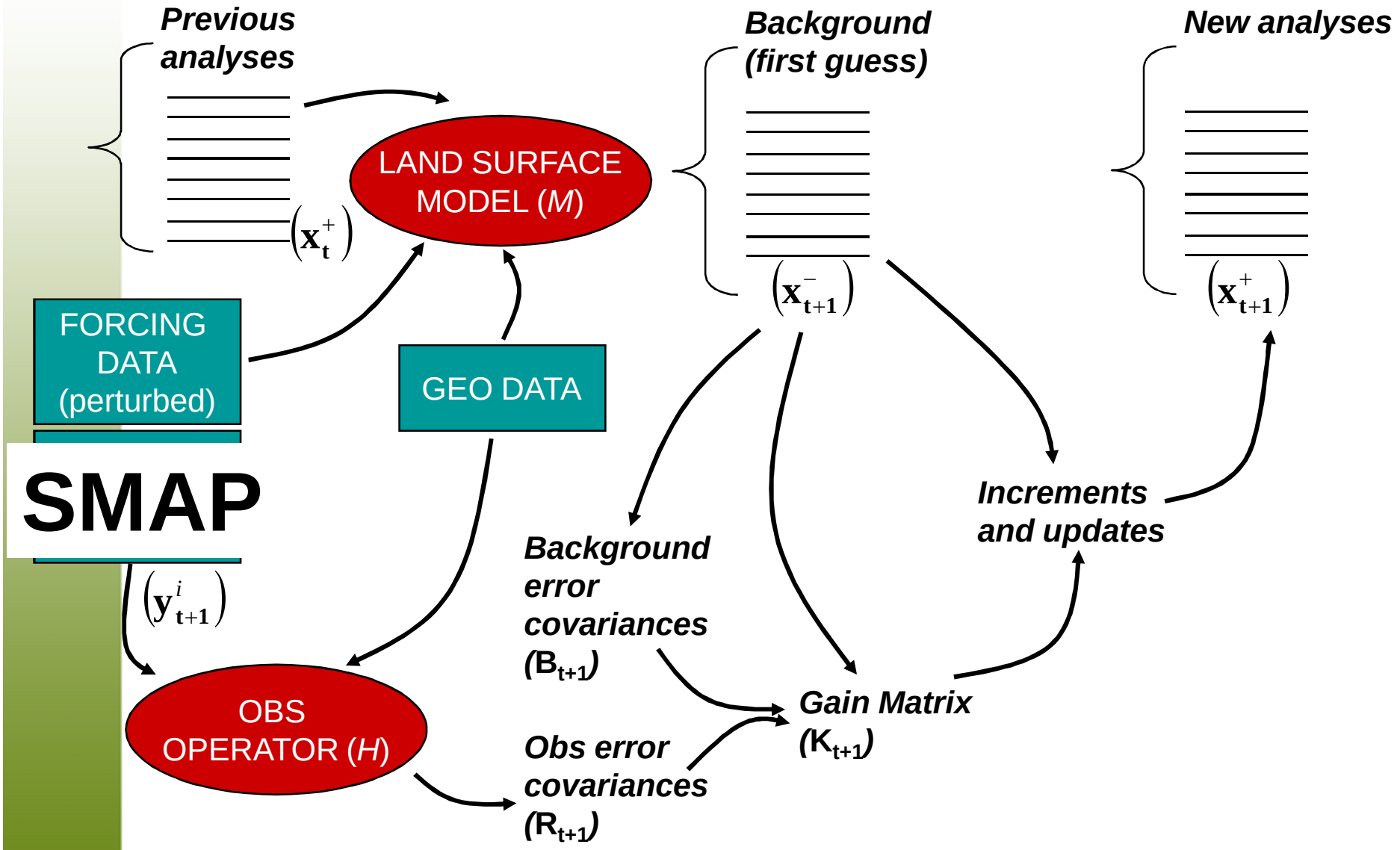


ANCILLARY DATA for the ASSIMILATION of SMAP DATA

FORCING DATA (perturbed)

Analyses or best estimates of:

- ***Precipitation (quantity and phase)***
- ***Radiation incident at surface (LW and SW – direct and diffuse)***
- ***Low-level air temperature***
- ***Low-level air humidity***
- ***Low-level winds***

GEO DATA

Information on:

- ***Orography (DEM)***
- ***Land / water coverage fractions (databases)***
- ***Soil texture (databases)***
- ***Vegetation type (databases / remote sensing)***
- ***Vegetation conditions, i.e., LAI (analysis based on remote sensing)***
- ***Urban cover types (databases)***
- ***Snow conditions, i.e., coverage at least (analyses)***
- ***Surface temperature (analyses)***

RESEARCH and DEVELOPMENT ISSUES

Assimilation of SMAP data

Specification of background and observations error covariances

Role and impact of other data (i.e., screen-level obs)

Impact of SMAP data

Impact on boundary layer, clouds, and precipitation is expected

Impact on large-scale upper-air features?

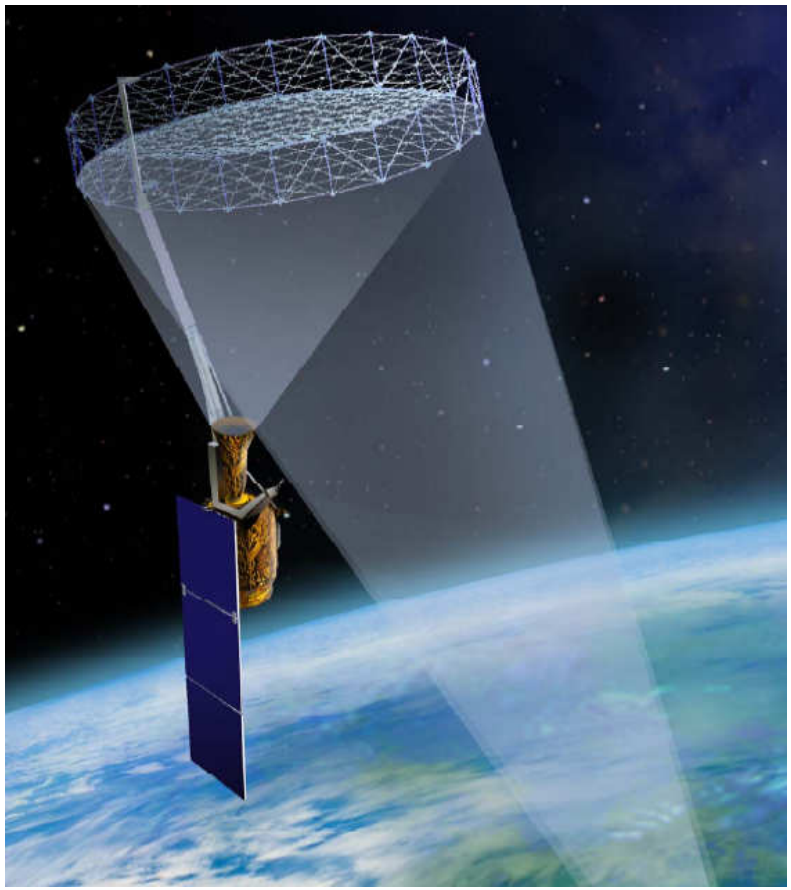
Ancillary data

Atmospheric forcing (e.g., precipitation) of crucial importance

Geophysical data (soil texture not that good)

Vegetation analysis (combination of satellite and model products)

THANK YOU for your ATTENTION



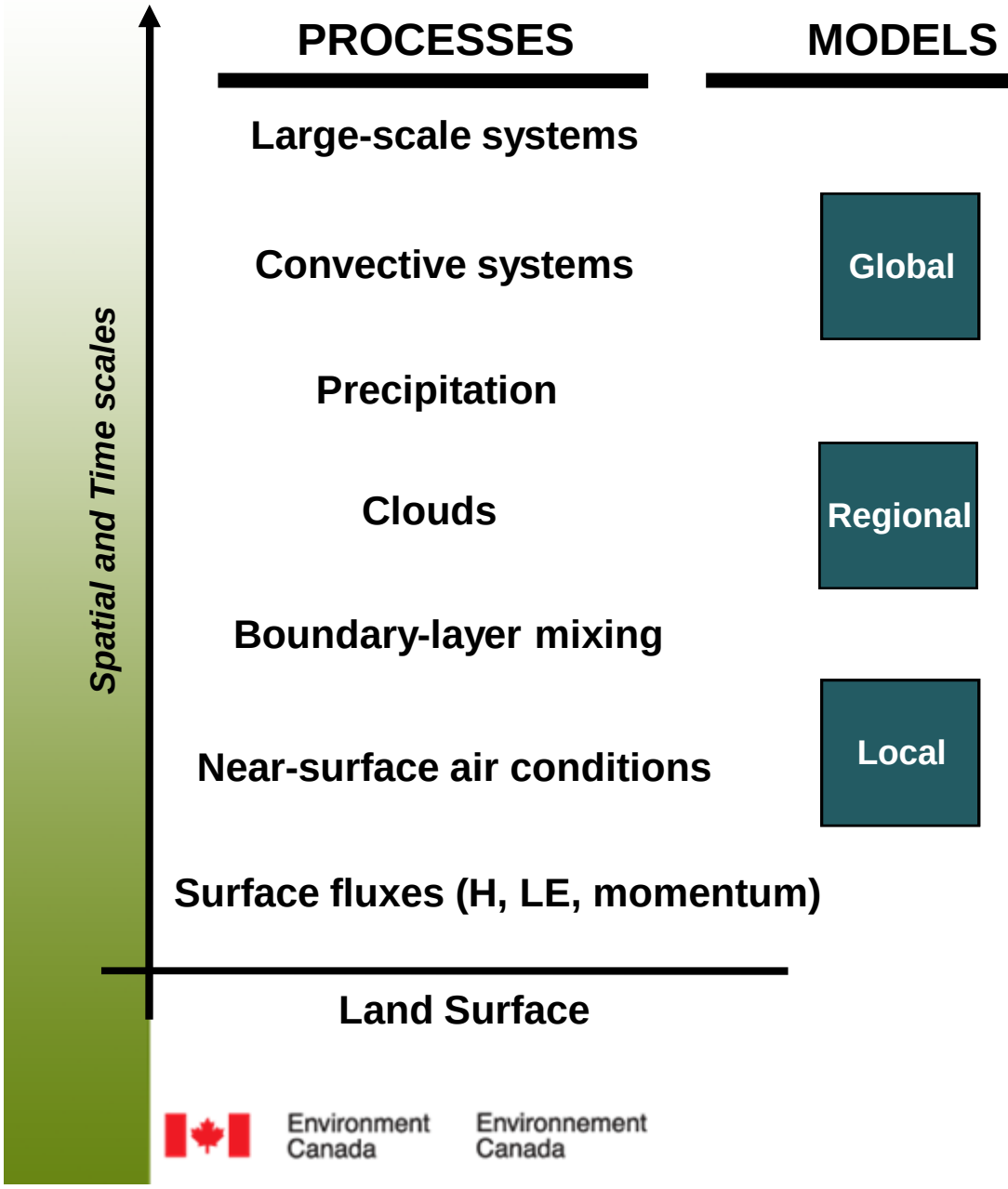
SOIL MOISTURE at ENVIRONMENT CANADA
HISTORICAL PERSPECTIVE

1986	***Force-restore scheme with a time-evolving "soil wetness" variable. Initial conditions provided by a "climatology"***
1995	***Simple assimilation of soil moisture based on screen-level air temperature and humidity***
2001	***Land surface scheme with a soil moisture variable. Improved method for the initial conditions, but still based on screen-level data (regional, short-range system)***
2006	***Same but for the global, medium-range system***

ASSIMILATION of SPACE-SPACE REMOTE SENSING DATA

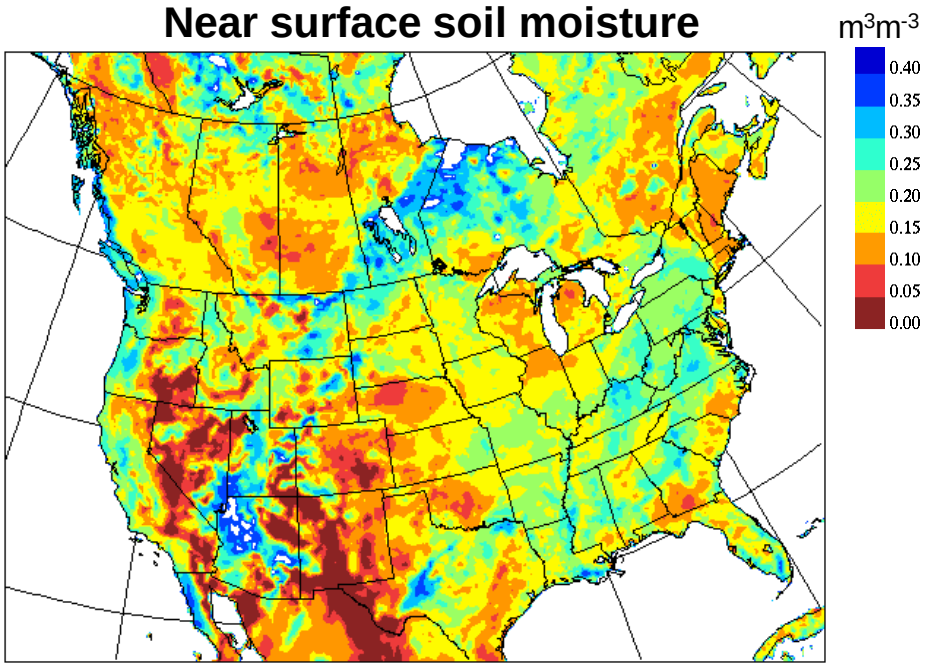
2011?	***Assimilation of SMOS passive data***
2014?	***Assimilation of SMAP passive and active data***

SOIL MOISTURE and NUMERICAL WEATHER PREDICTION

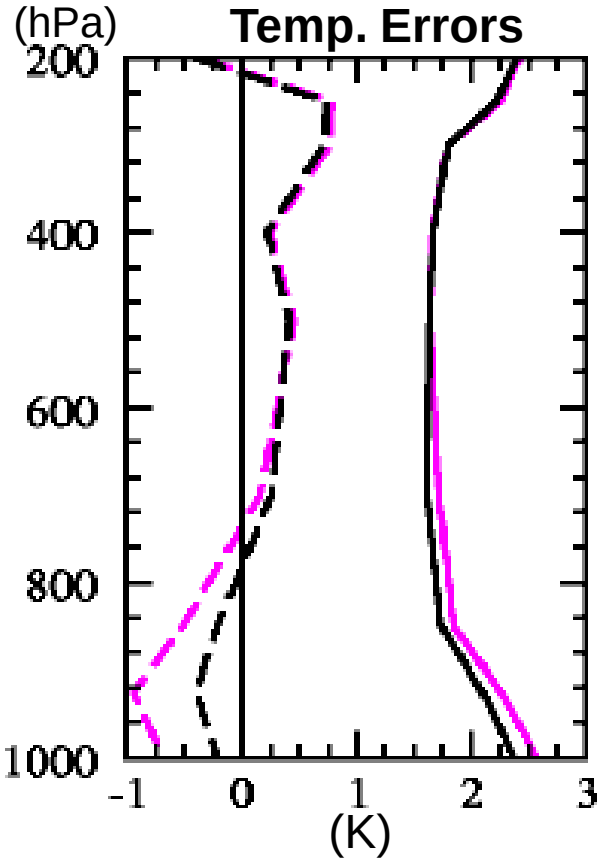


- *Determine exchanges of heat, water, and momentum between the surface and the atmosphere*
- *Impact on near-surface conditions, boundary-layer mixing, clouds, precipitation, and maybe even large-scale systems*
- *Important for local, continental, and global models, … at short, medium, and long ranges*
- *Land surface is even more important for new environmental systems now in development at EC, e.g., external land surface system, hydrology.*

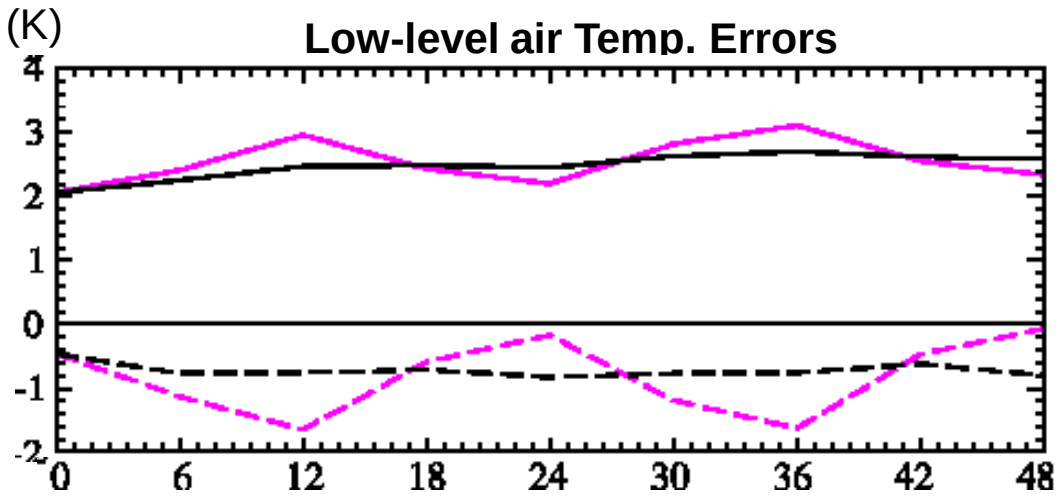
IMPACT on NEAR SURFACE and BOUNDARY LAYER

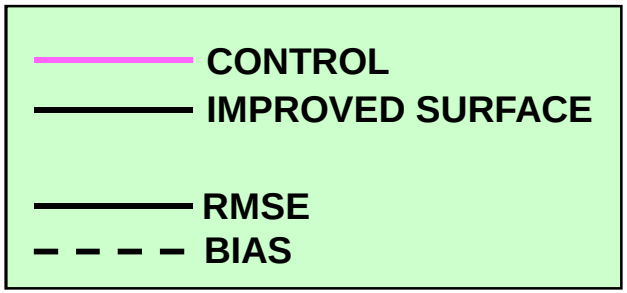


(valid at 1200 UTC 22 October 2004)



48-h integrations





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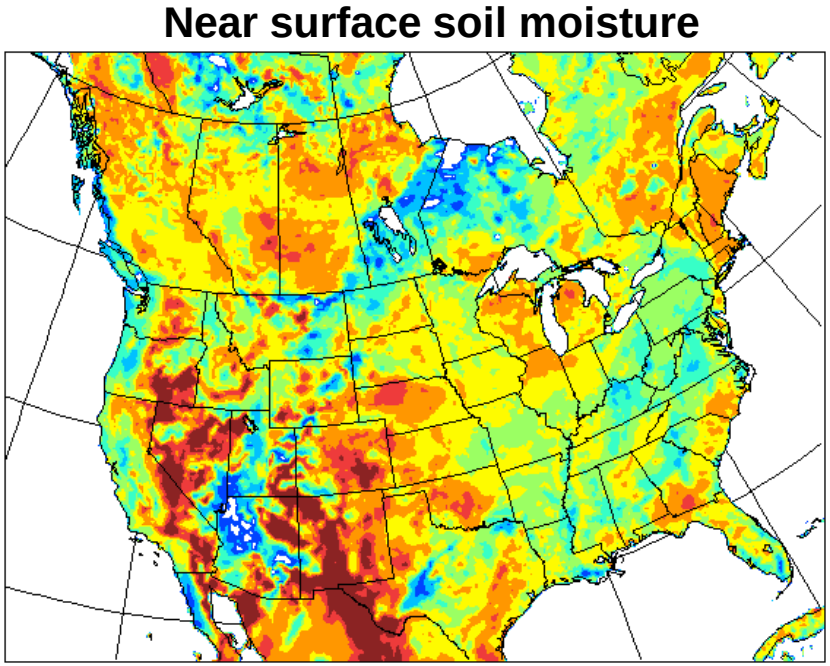
(*Bélair et al*. 2003)

Canada

IMPACT on NEAR SURFACE and BOUNDARY LAYER



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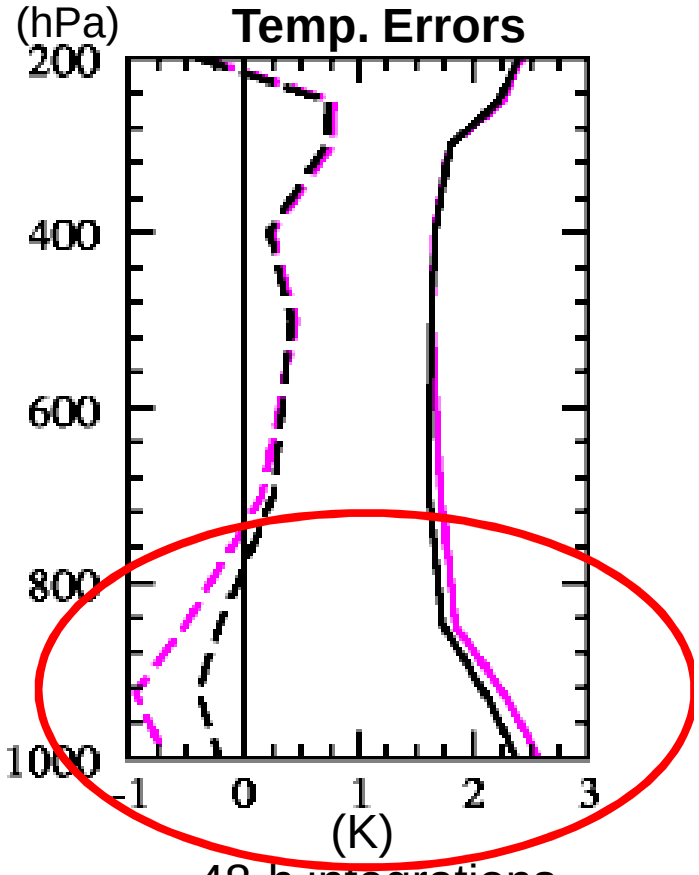

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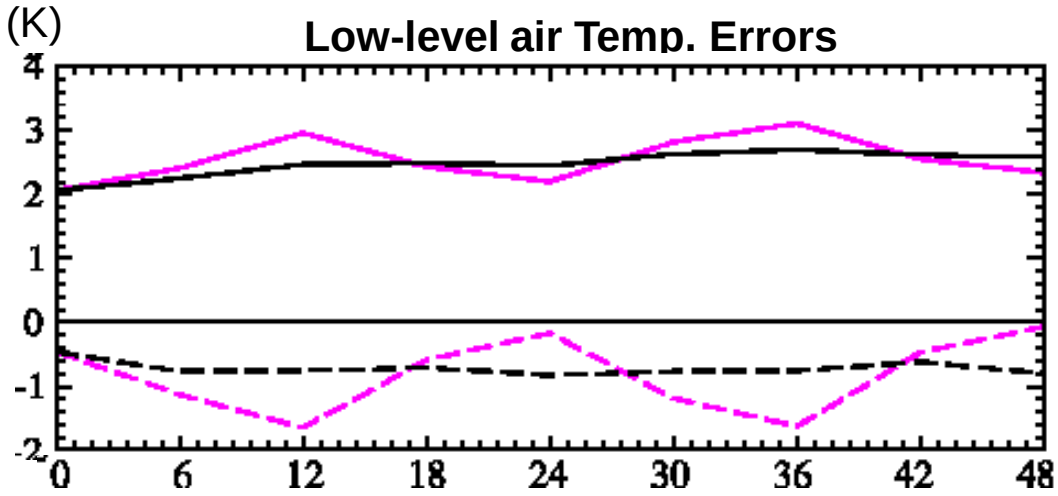

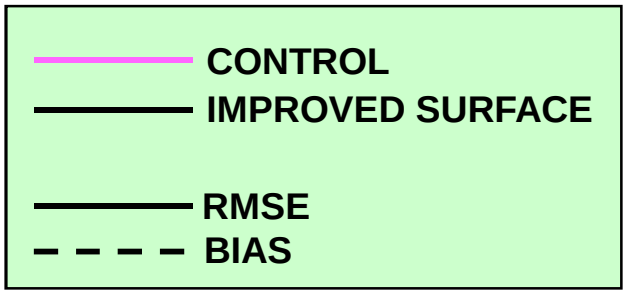

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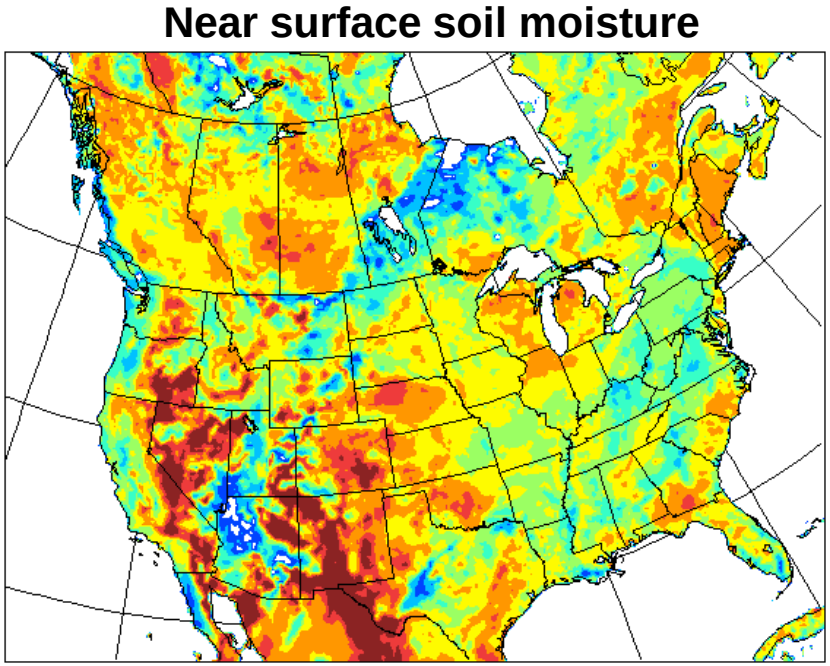
IMPACT on NEAR SURFACE and BOUNDARY LAYER



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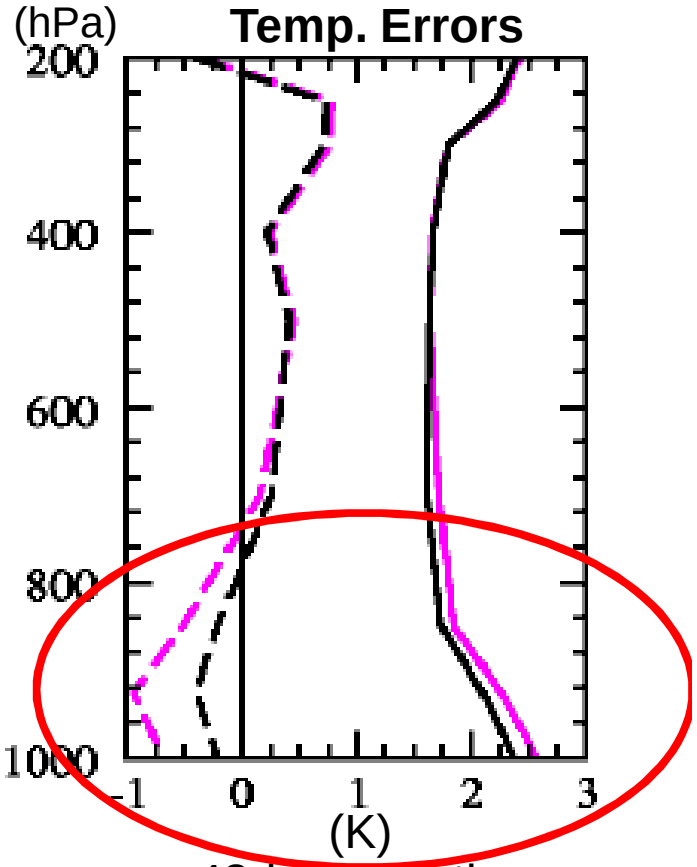

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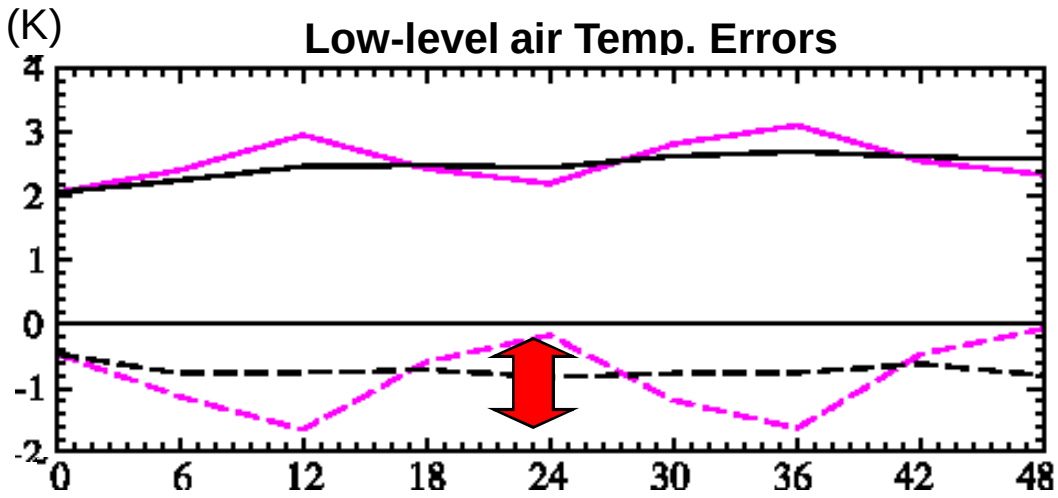
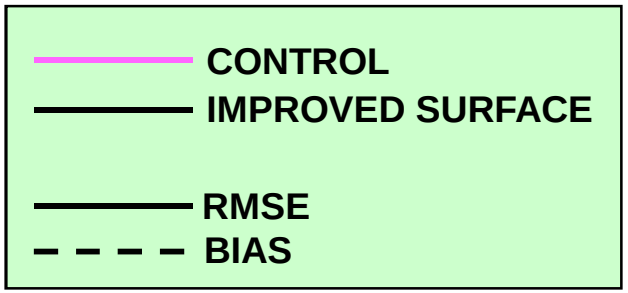




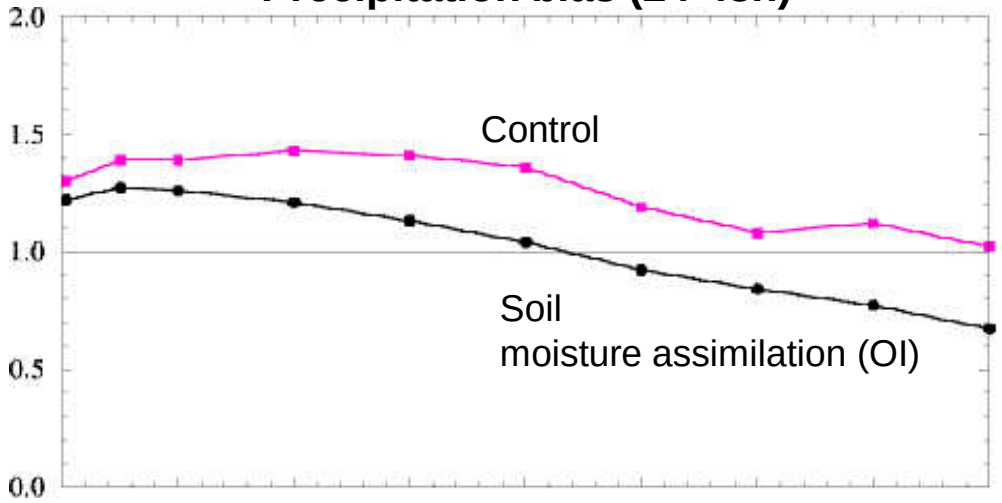
Environment Canada Environnement Canada

(*Bélair et al*. 2003)

Canada

IMPACT on PRECIPITATION

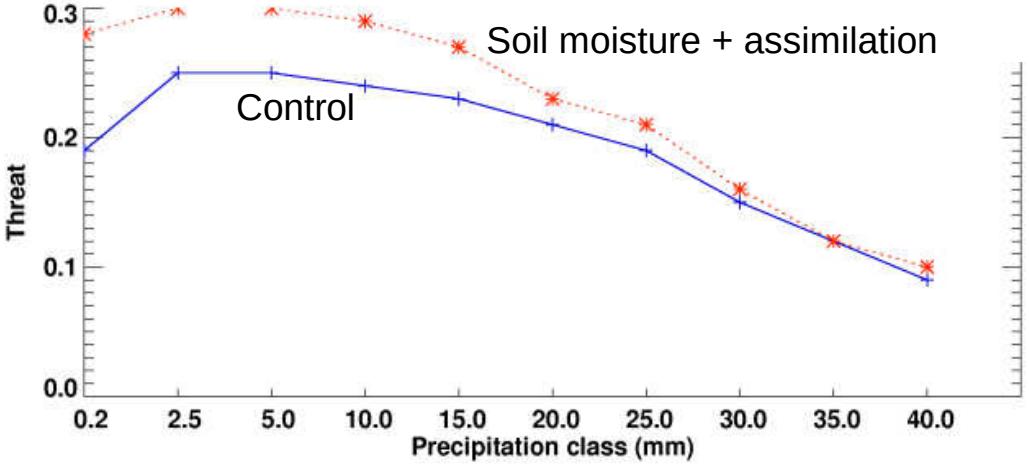
Precipitation bias (24-48h)



REGIONAL FORECASTING SYSTEM (2001)

48 CASES

Precipitation Threat Score (Day 4)- SHEF (US)



GLOBAL FORECASTING SYSTEM (2006)

116 CASES

THERMODYNAMIC versus MOMENTUM SURFACE FLUXES

... Based on our experience at EC

THERMO

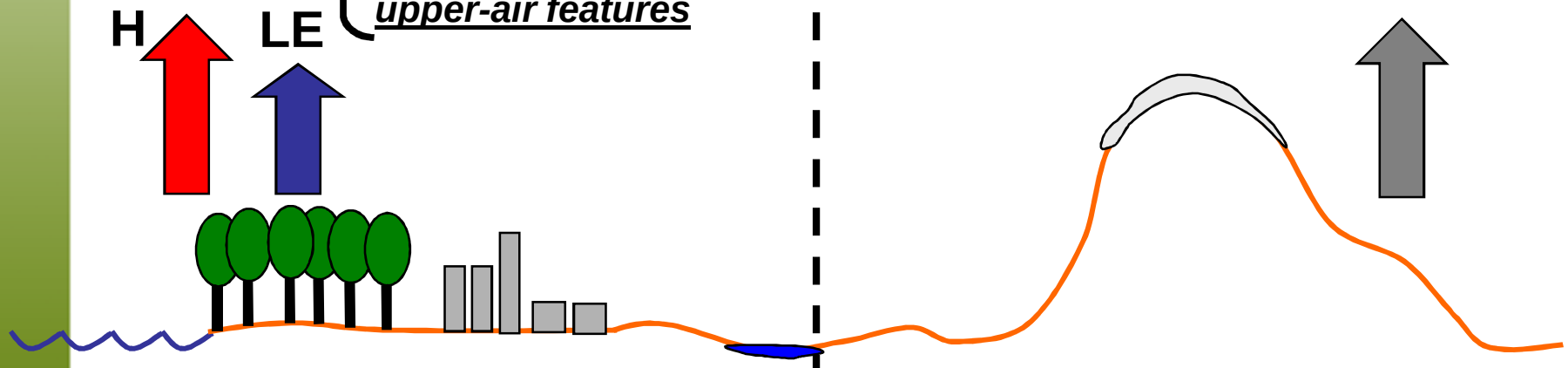
- H and LE surface fluxes
- Surface temperatures
- Soil moisture
- Water / land fractions

Significant impact on boundary layer, clouds, and precipitation. But not clear yet how it influences large-scale upper-air features

MOMENTUM

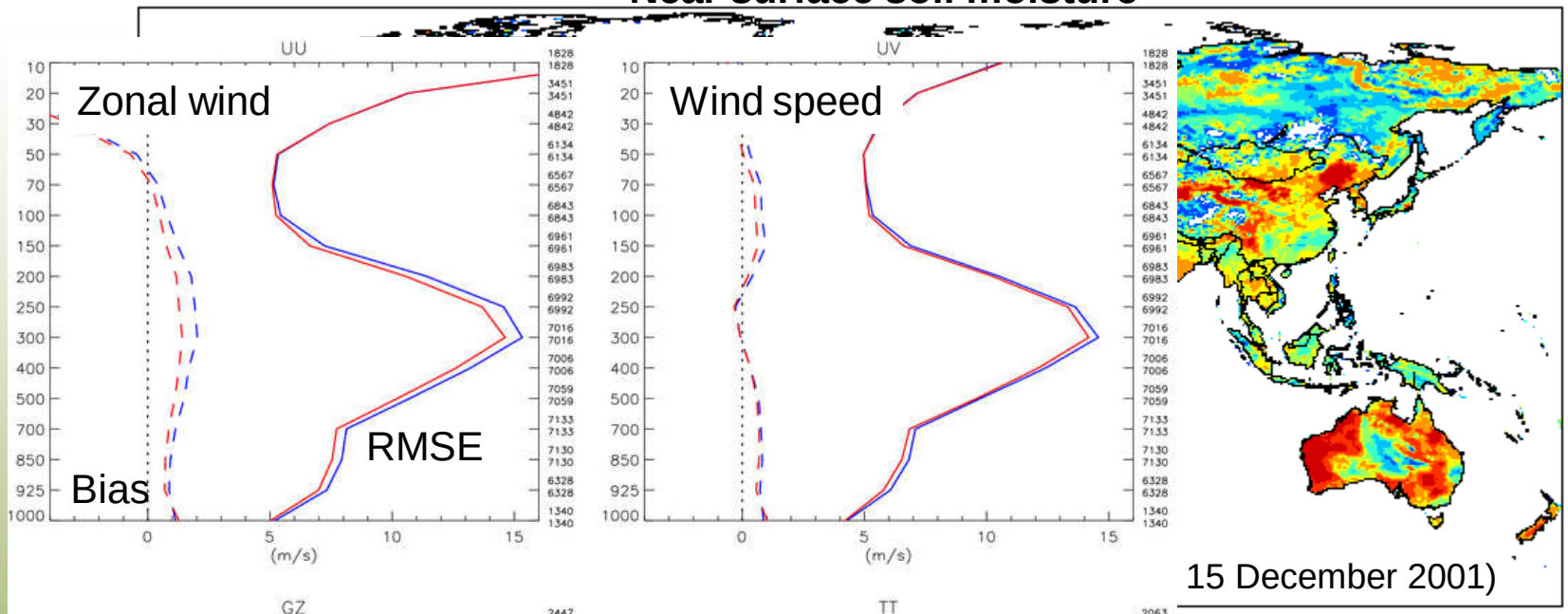
- Resolved orography
- Blocking effect (subgrid-scale)
- Turbulent mixing (subgrid-scale)

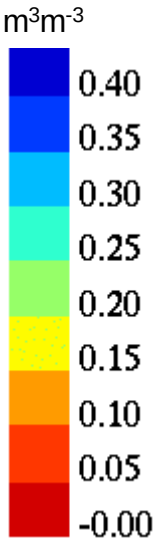
Significant impact on large-scale features, but not on clouds and precipitation



POSSIBLE IMPROVEMENT at MEDIUM-RANGE (GLOBAL MODEL)

Near surface soil moisture





Global

Medium-Range prediction system

116 cases

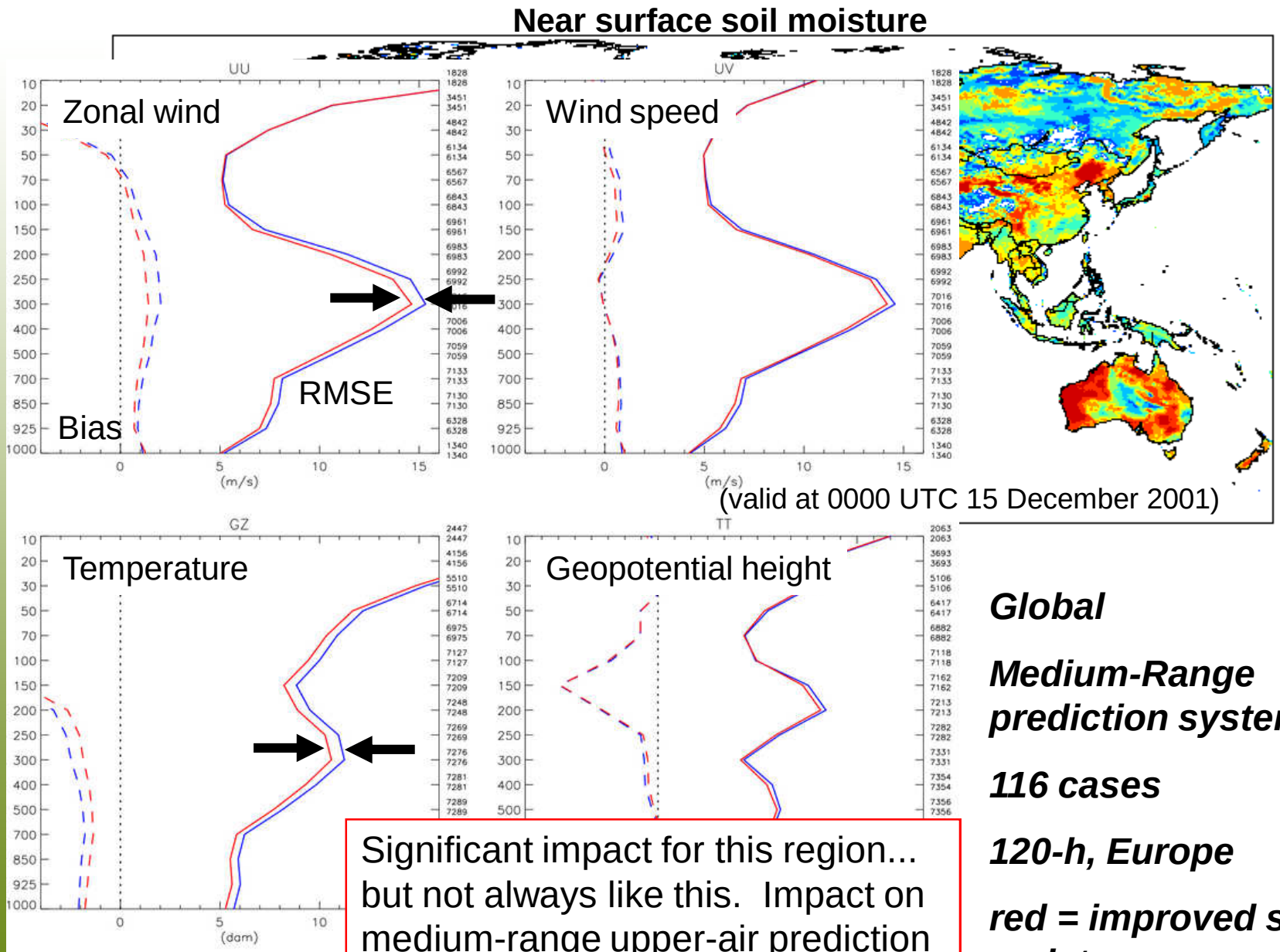
120-h, Europe

red = improved soil moisture

Environment Canada | Environnement Canada

Canada

POSSIBLE IMPROVEMENT at MEDIUM-RANGE (GLOBAL MODEL)



Significant impact for this region... but not always like this. Impact on medium-range upper-air prediction still TBD

Global

Medium-Range prediction system

116 cases

120-h, Europe

red = improved soil moisture

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