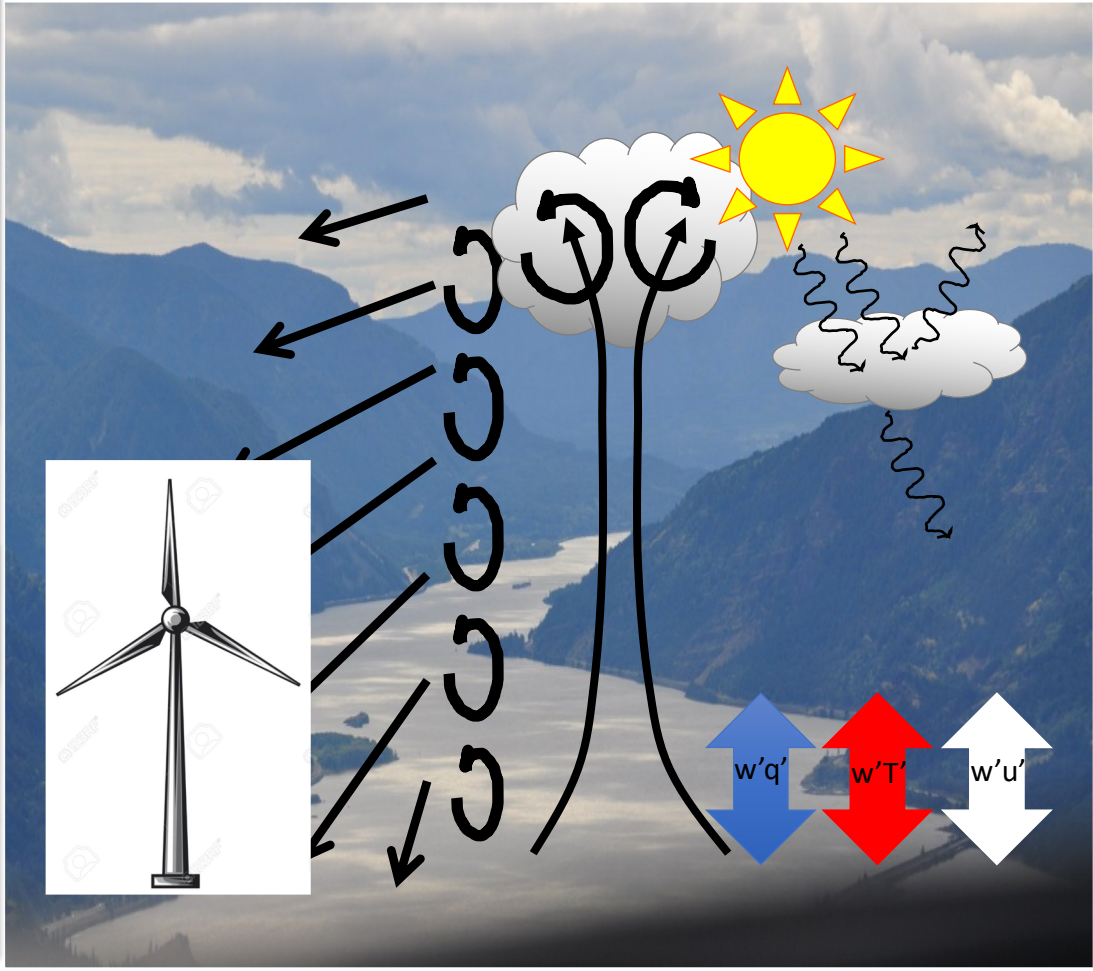
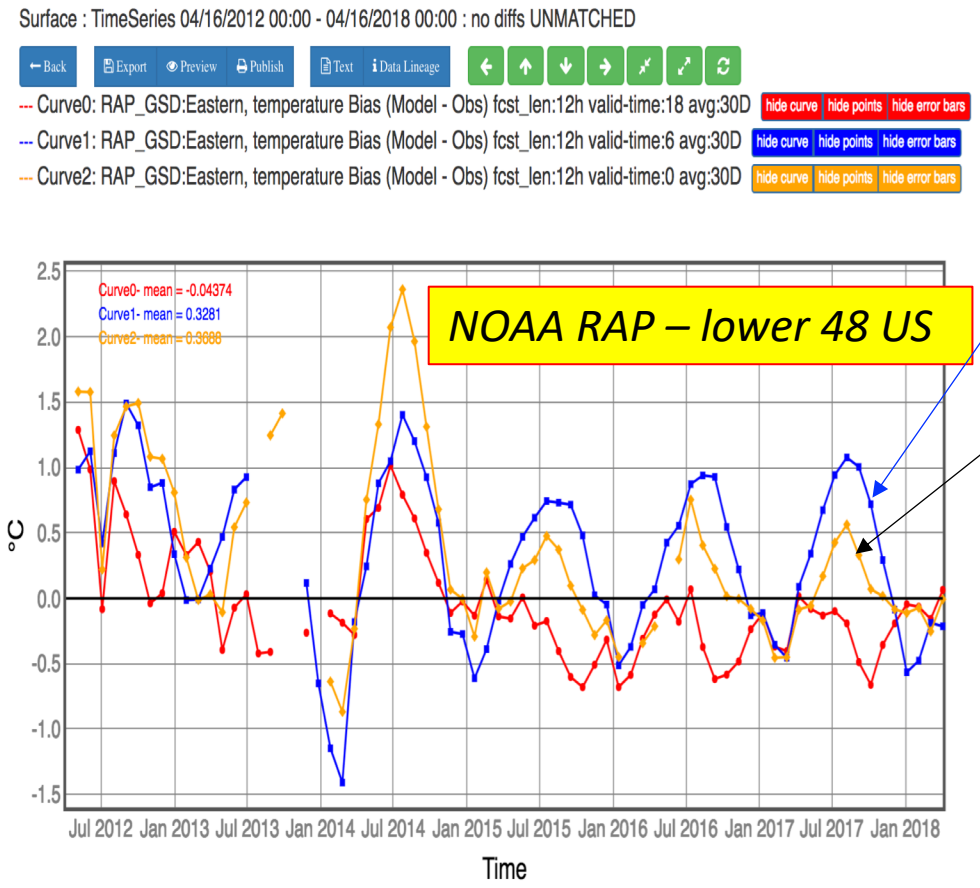
HRRR/RAP: Physical Processes and Representations

Process	Model Component	Change/Addition
Turbulent Diffusion	MYNN PBL/ 3d-Blended TKE	• Mixing length ○ Scale-aware ○ Z-less
Non-local Turbulent Transport	MYNN Mass-flux	• Multi-plume • TKE transport • Momentum transport • Scale-aware
Surface Fluxes	RUC LSM/ MYNN Sfc Layer	• Scalar roughness • M-O alternatives
Clouds	Thompson Aerosol / Chaboureau-Bechtold	• Subgrid scale clouds • Coupled to radiation • prognostic
Numerics/ Dynamics	Vertical Coordinate, Advection	• Hybrid WRF-ARW Vertical Coordinate
Turbine Drag	Wind Farm Parameterization	• Wind direction effects • Power calculation.





RAP diurnal 2m temp biases (12h) - *similar to ECMWF IFS (60- 72h) forecasts.*

- ***Night (06z for US)***
  - cold bias in winter
  - warm bias in summer
- ***Day*** – slight cool bias (18z for US)
- ***End of day*** – 00z-US –warm bias summer

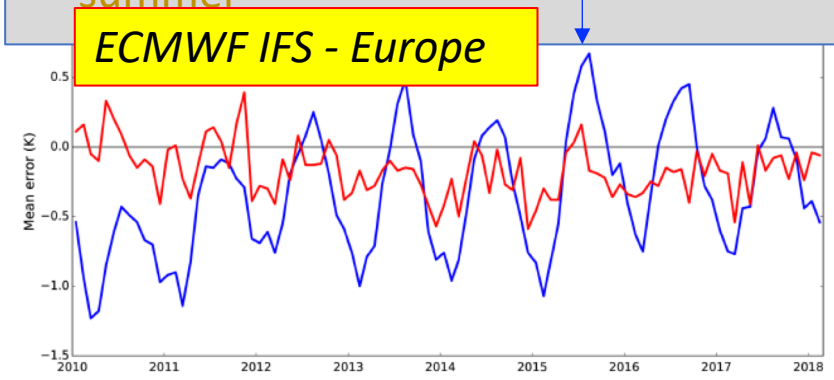


Figure 1: Nighttime (blue) and daytime (red) bias of the ECMWF HRES 2m temperature forecast in Europe. Lead times are 60 h and 72 h, respectively.

From Thomas Haiden - ECMWF

CAUSES - Clouds Above the United States and Errors at the Surface

About
Experiment
Timetable
News
Contact

What is CAUSES?

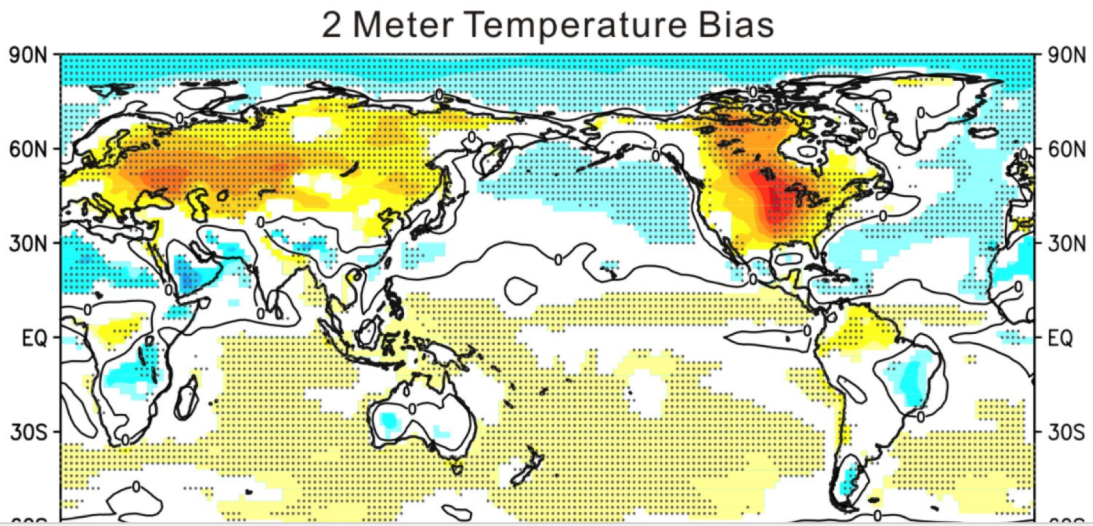
Any progress?

Purpose

The Clouds Above the United States and Errors at the Surface (CAUSES) is a joint GASS-RGCM-ASR mod
intercomparison project with an observationally-based focus, which evaluates the role of clouds, radiation an
precipitation processes in contributin to the surface temperature biases in the region of the central United Sta
These biases are seen in several weather and climate models.

GASS GEWEX Global Atmospheric System Studies
RGCM
ASR Atmospheric System Research

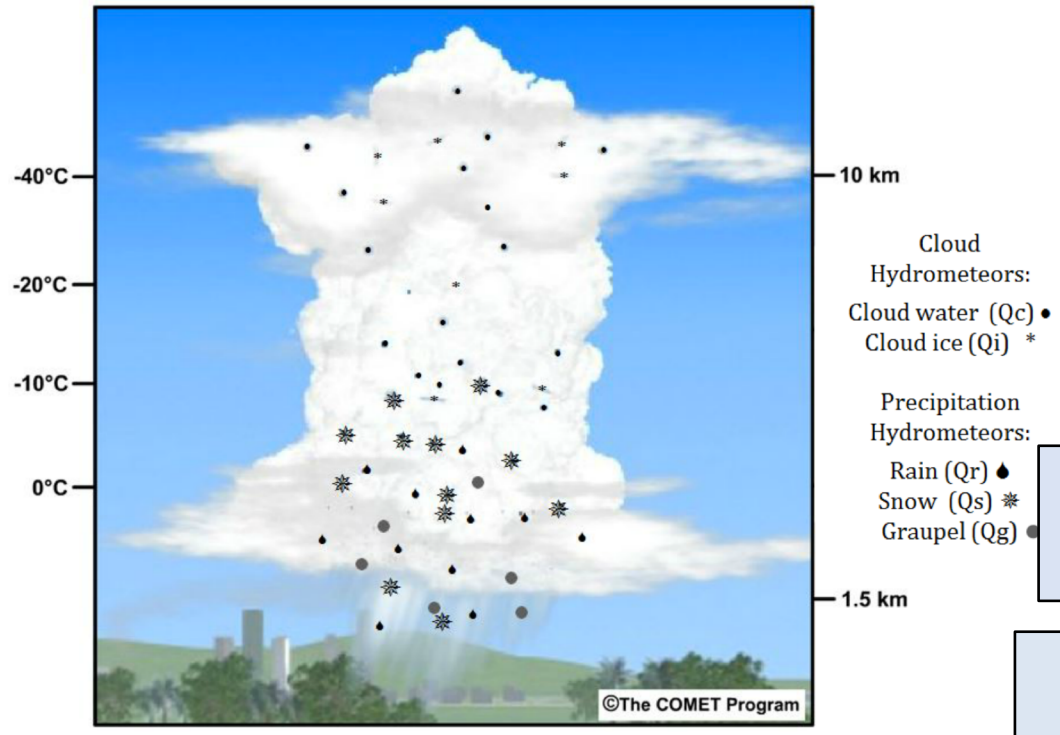
Led by:
UKMO – Cyril Morcrette
DOE – US – Steve Klein



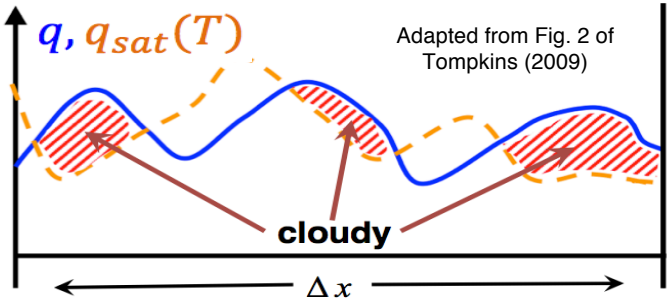
Physics Development Emphasis: Sub-Grid Clouds – MYNN PBL

Explicit (Resolved) Clouds/Precipitation

RAP and HRRR use the Thompson microphysics scheme with 5 hydrometeor types



Sub-Grid (Unresolved) Clouds



$$Var(s) \propto Var(q) + Var(T) - Cov(q,T)$$

Assume PDF of *s (saturation ratio)*

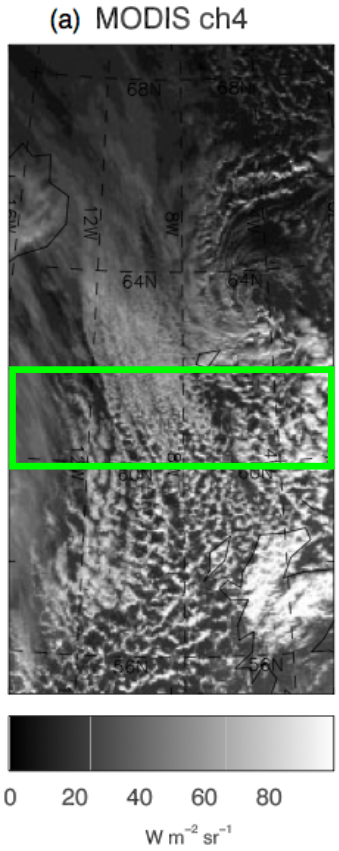
Parameterize: *assume* subgrid PDFs for thermodynamic variables Chaboureau-Bechtold (2002)

Retrieve Cloud Fraction, Cloud Condensate

Joseph Olson
NOAA/ESRL/GSD

Scale-aware representation-subgrid-scale clouds

Shortwave up at Top Of Atmosphere

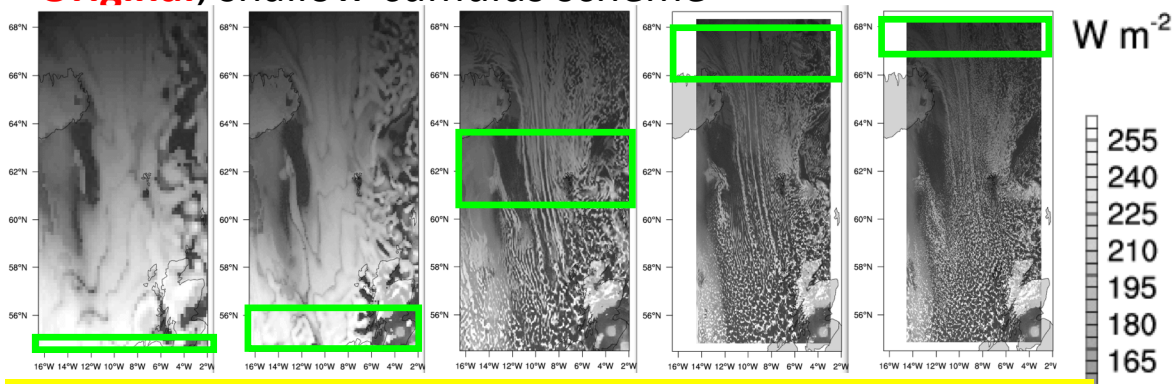


Above figure taken from Field et al (2013) – 12 UTC 31 Jan 2010.

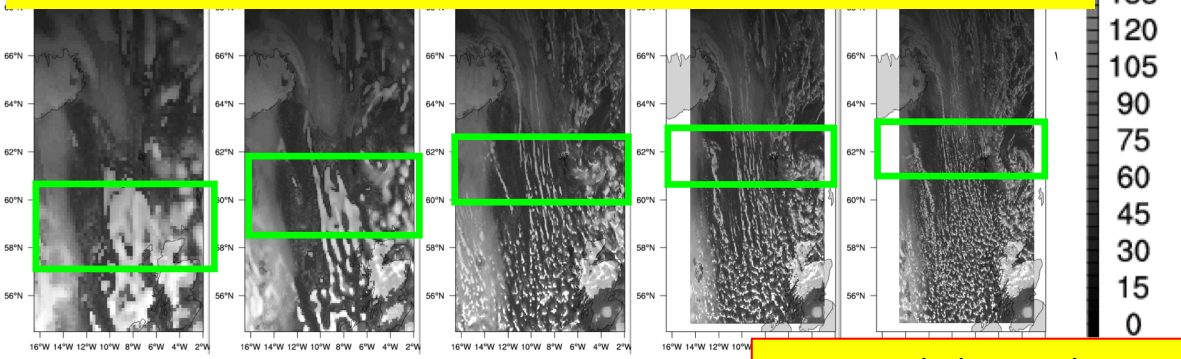
Δx =

15km 8km 4km 2km 1km

Original; shallow-cumulus scheme

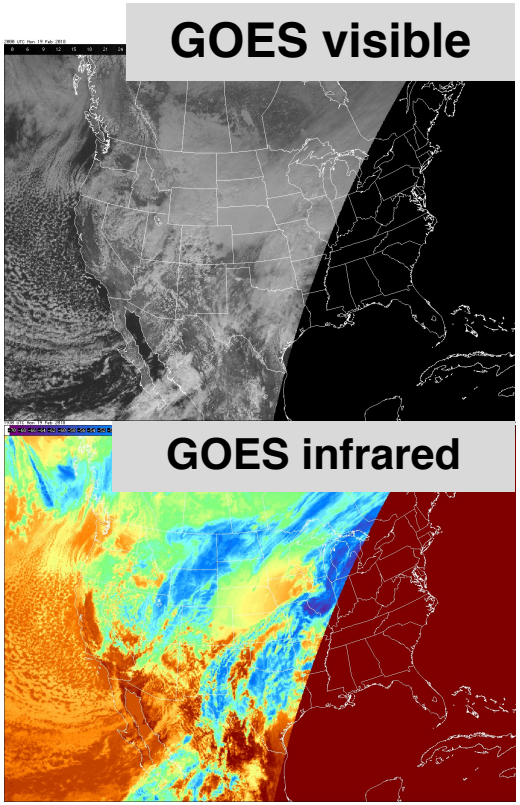


New MYNN-EDMF scheme with subgrid clouds



MYNN turbulence scheme
- Joseph Olson, Jaymes Kenyon - GSD

Cloud/radiation experiments w/ 3km HRRR - cloud-water path



Diff CWP [g m^{-2}]

remove limit on nonconvective q_{cloud}

reduce r_e for subgrid clouds

HRRR 8-h forecasts valid 2000 UTC 19 Feb 2018

combined cbanges

Decreased CWP

-240 -180 -120 -60 0 60 120 180 240

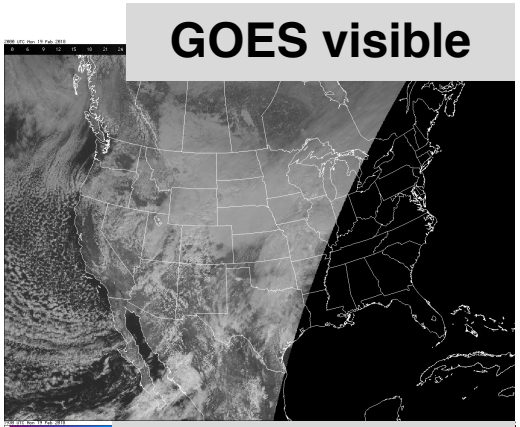
Increased cloud water path

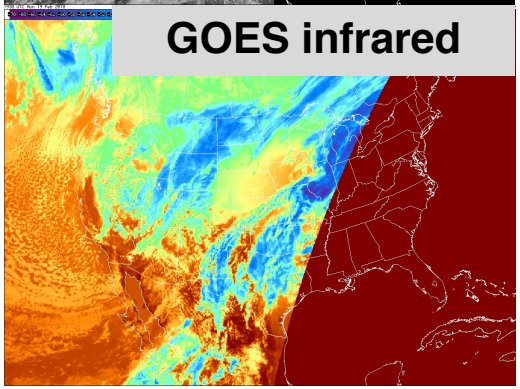
1. **Reduce cloud-droplet effective radius for subgrid clouds:**

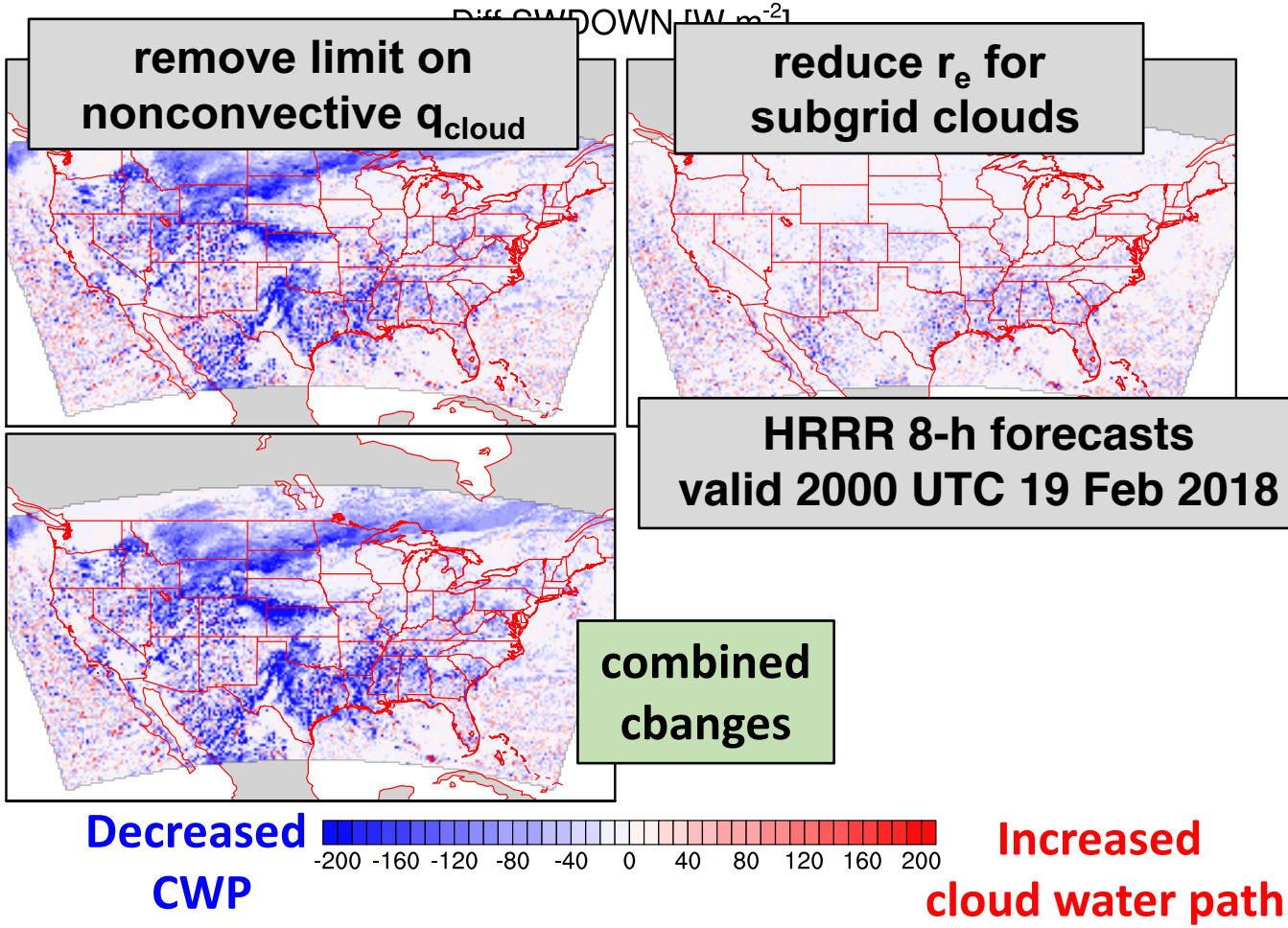
- **land: reduce 7.5 -> 5.4 μm, water: reduce 10.5-> 9.6 μm (Miles et al 2000)**

2. Remove 5% sat vap pressure (SVP) constraint on q_{cloud} for subgrid clouds (MYNN)

Cloud/radiation experiments w/ 3km HRRR – downward SW rad







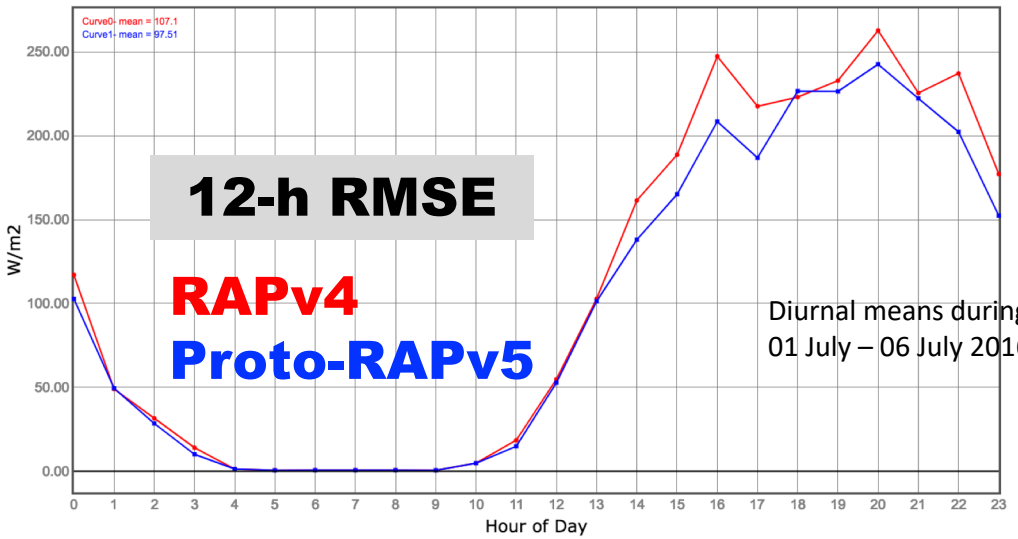
1. **Reduce cloud-droplet effective radius for subgrid clouds:**
- **land: reduce 7.5 -> 5.4 μm, water: reduce 10.5-> 9.6 μm (Miles et al 2000)**

2. Remove 5% sat vap pressure (SVP) constraint on q_{cloud} for subgrid clouds (MYNN)

Surface GHI (global horizontal irradiance)

Cloud/radiation exp w/ 13km RAP - 1-6 July 2016

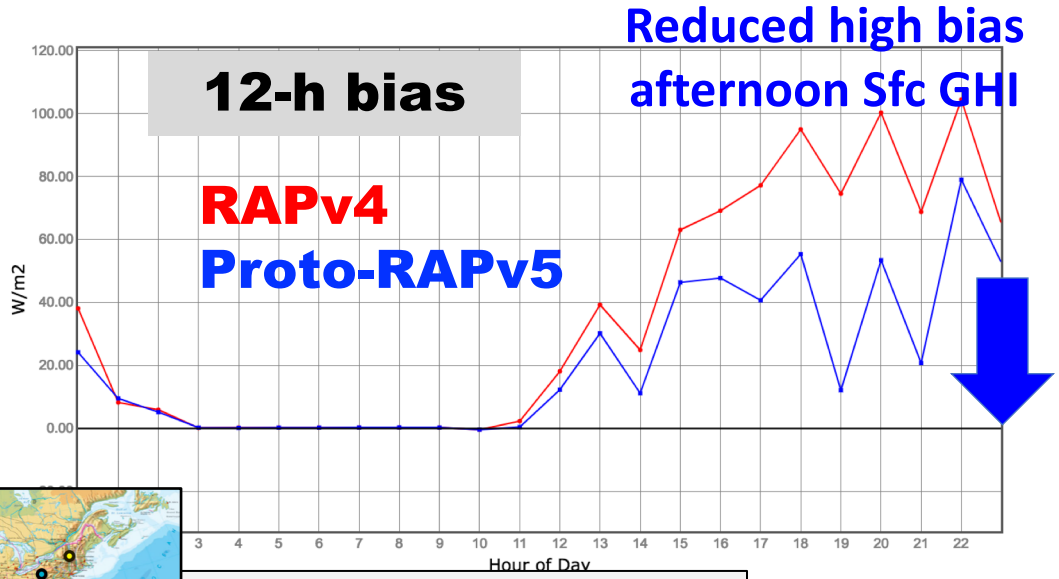
Downward SW rad



1. Reduce cloud-droplet effective radius for subgrid clouds:

- use mean values from Miles et al. (2000)
- land: reduce from 7.5 to 5.4 μm
- water: reduce from 10.5 to 9.6 μm

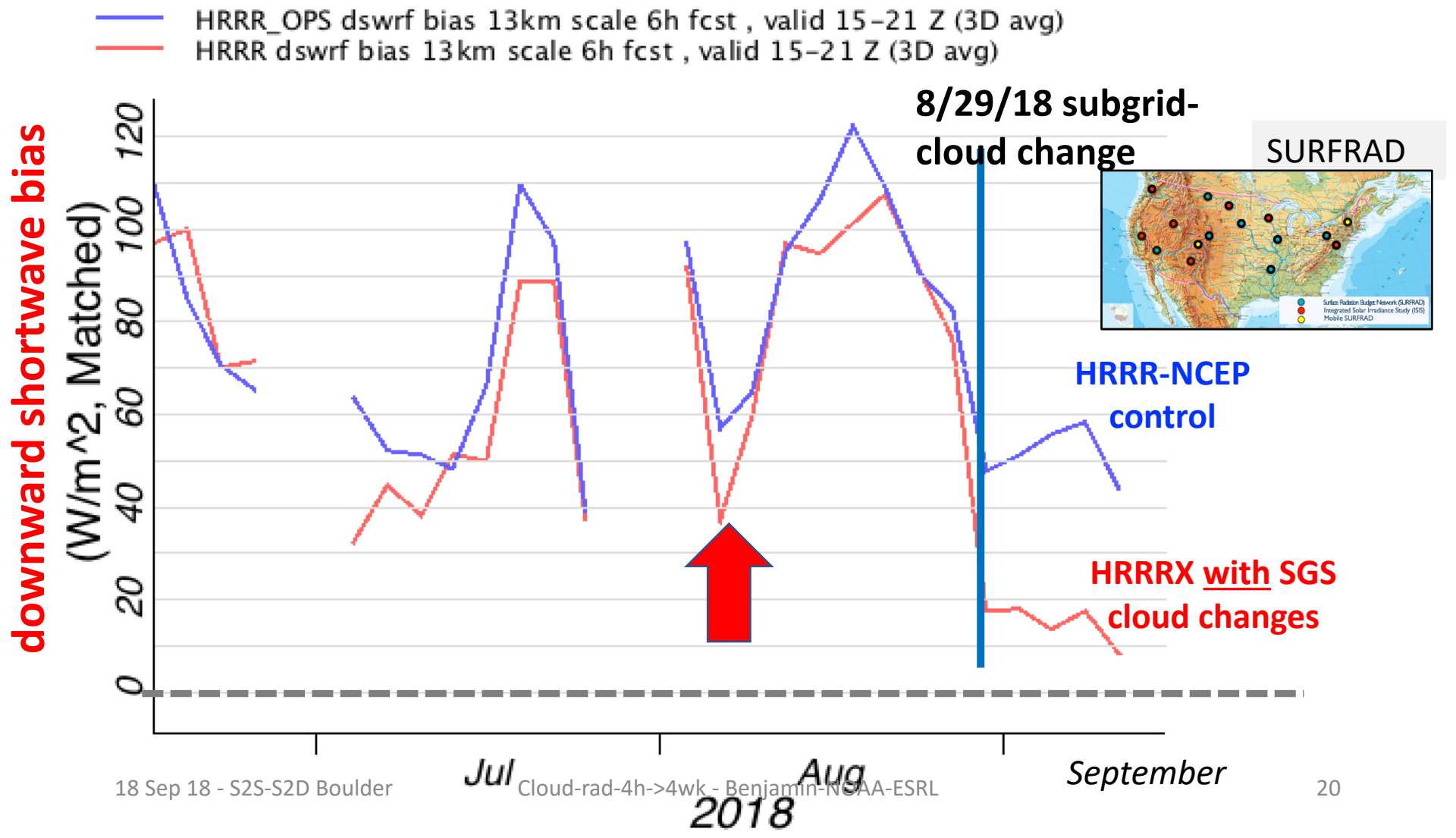
2. Remove 5% sat vap pressure (SVP) constraint on q_{cloud} for subgrid clouds (MYNN PBL scheme)



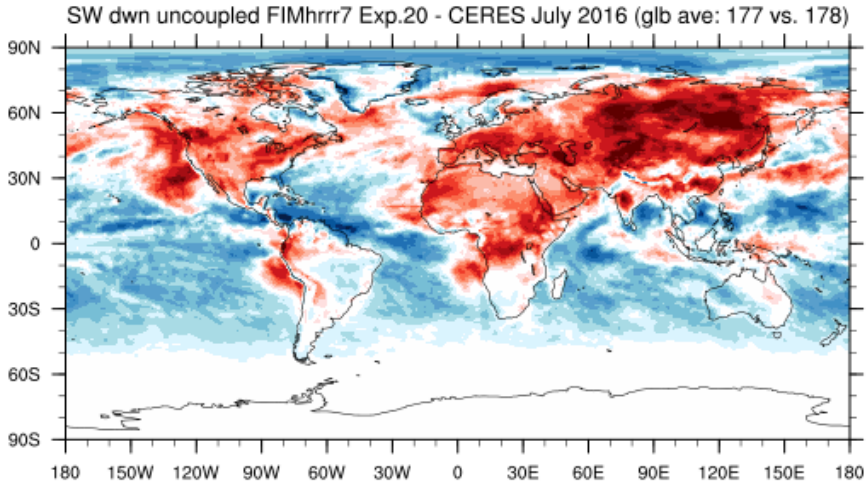
SURFRAD – 14 stations – NOAA/ESRL/GMD

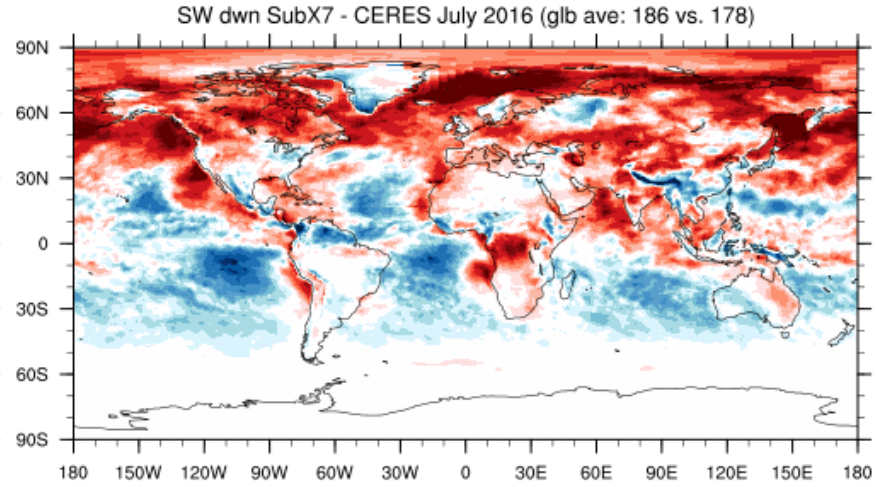
Real-time experimental 3km HRRR results - downward shortwave bias

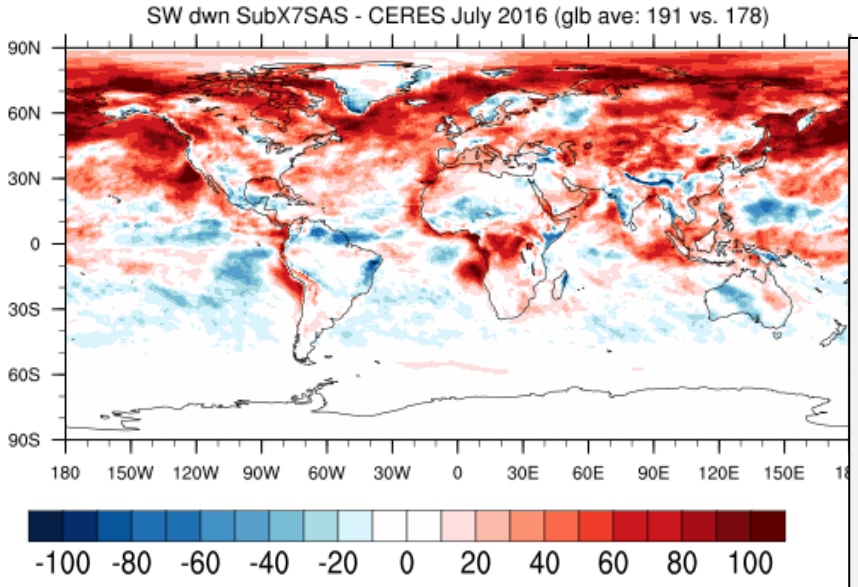
Intro of MYNN cloud-water/radius changes into GSD real-time HRRR



Downward SW biases – July 2016



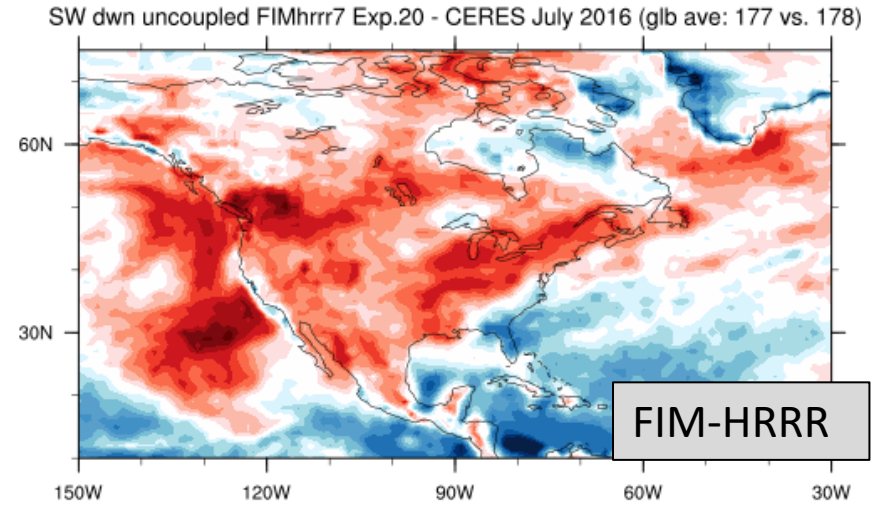


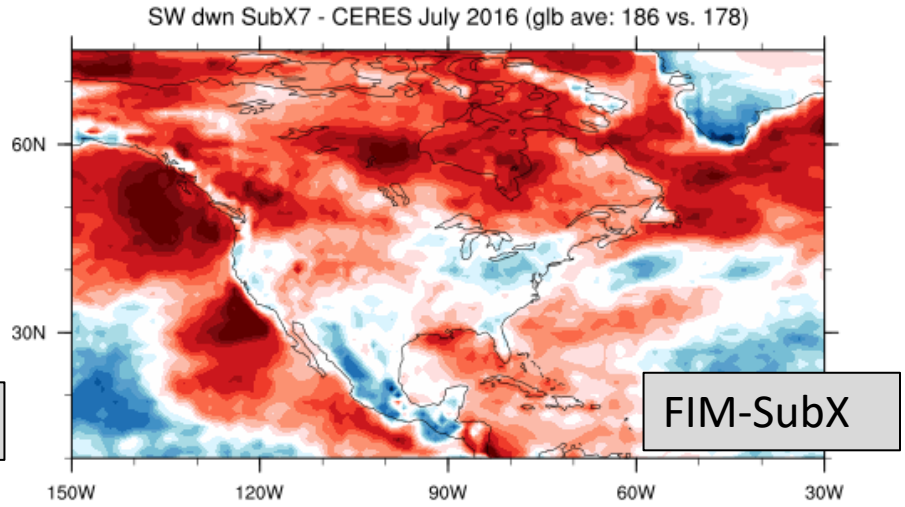


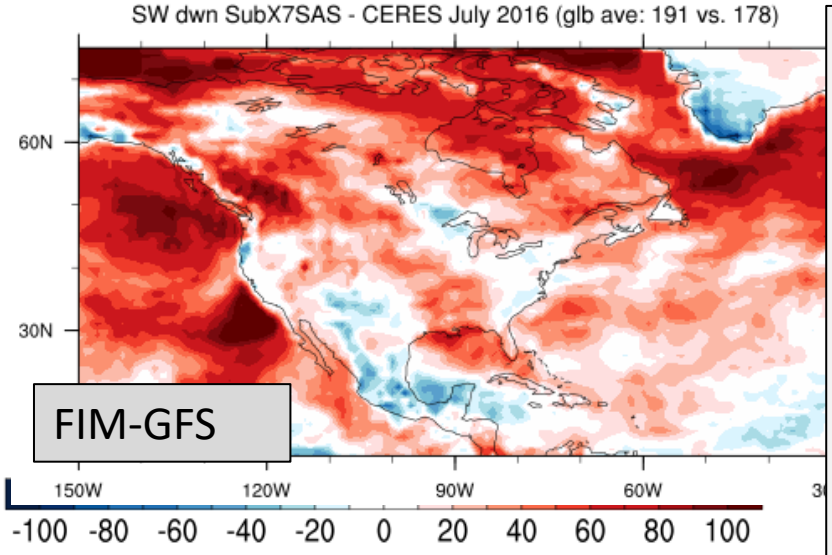
Total Down SW radiation –Jul 2016

- CERES ("observed") – 178 W/m^2
- FIM-GFS(w/ SAS conv) 191
- FIM-SubX – GFS+Grell 186
- FIM-HRRR-MYNN-Grell 177
- " before SGS cloud mod 186

Downward SW biases – July 2016 – N. America





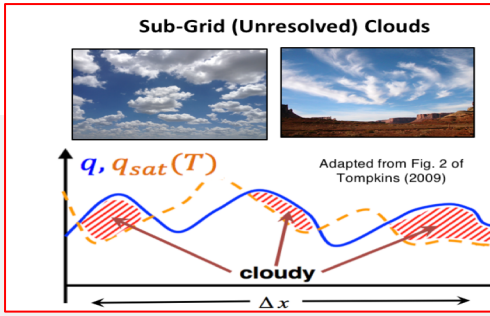


Total Down SW radiation –Jul 2016

- CERES ("observed") – 178 W/m^2
- FIM-GFS(w/ SAS conv) 191
- FIM-SubX – GFS+Grell 186
- FIM-HRRR-MYNN-Grell 177
- " before SGS cloud mod 186

S2S testing – initial-only progress with scale-aware SGS clouds.
Better over higher-latitude land and ocean, not over lower 48 US.

Summary



- Warm bias in central US in models
  - Qt all time scales (climate, medium-range, S2S, CAM-short), not just in US, even 3km HRRR NWP model
  - Sub-grid-scale (SGS) clouds needed down to ~200m dx
- Common development and testing of scale-aware physics parameterization suite at NOAA/ESRL from storm-scale to S2S
- Progress on SGS clouds in MYNN PBL – qc limit removed, droplet radius
  - Downward SW radiation bias from ~70 -> 10-20 W/m^2 for 3km HRRR over US
  - Subseasonal tests – initial tests – 187->178 W/m^2 NH (CERES obs – 177)
- Ongoing development of HRRR-RAP physics for 3km HRRR, FV3-NWP, subseasonal tests
  - Advanced physics parameterizations swappable thru Common Community Physics Package interface for NOAA, NCAR, US Navy (NRL) models
- Goal: seamless regional/global physics necessary for seamless storm-scale/ global NWP/S2S modeling
  - =>Test on all time scales and resolution including S2S.

See related posters/talk today
Shan Sun- P-A2-12,
Ben Green –P-A2-05.
Kathy Pegion – SubX – 1430.