Physics Upgrade of Q3FY17 NEMS GFS

- Use of higher resolution land surface climatologies and new surface albedo data.
- Updated land parameterization to reduced excessive cooling of 2m temperatures during sunset (00Z)
- Changes to cumulus convection parameterization to improve summertime precipitation forecasts.
- Included a Near Sea Surface Temperature (NSST) model to represent diurnal warming and sub-layer cooling effects.
- Reduced Rayleigh damping in the upper stratosphere to improve temperature and circulation forecast.

http://www.emc.ncep.noaa.gov/gmb/noor/GFS2017/GFS2017.htm

Land Surface Changes

- **IGBP 20-type land classifications and STASGO 19-type soil classifications**
- **New MODIS-based snow free albedo**
- **New MODIS-based maximum snow albedo**
- **Updated diurnal albedo treatment**
- **Unified snow cover and snow albedo between radiation driver and Noah LSM**
- **Fixed excessive cooling of T2m during sunset**
- **Increased ground heat flux under deep snow**

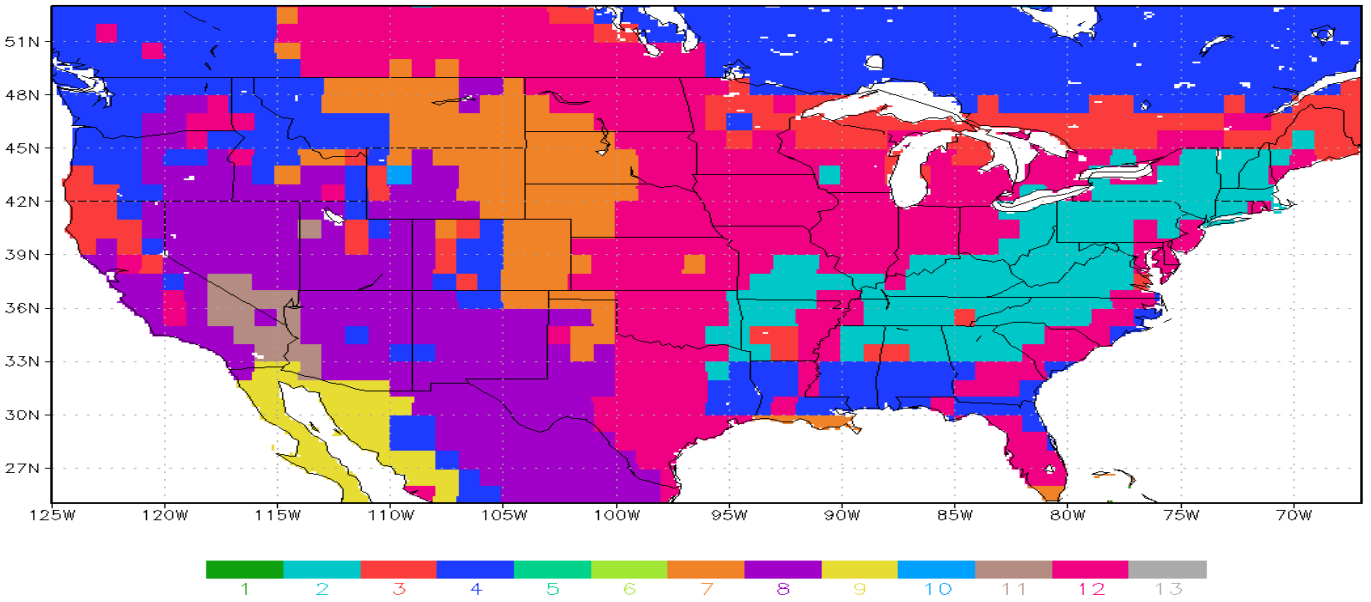
Major issue addressed:

- Reduced patchiness of land cover and its properties
- Reduced cold temperature bias over snow: Alaska, NW, NE
- Mitigated stable boundary layer decoupling
- Improved surface exchange coefficient (Ch)
- Removed excessive large snow albedo

Surface type

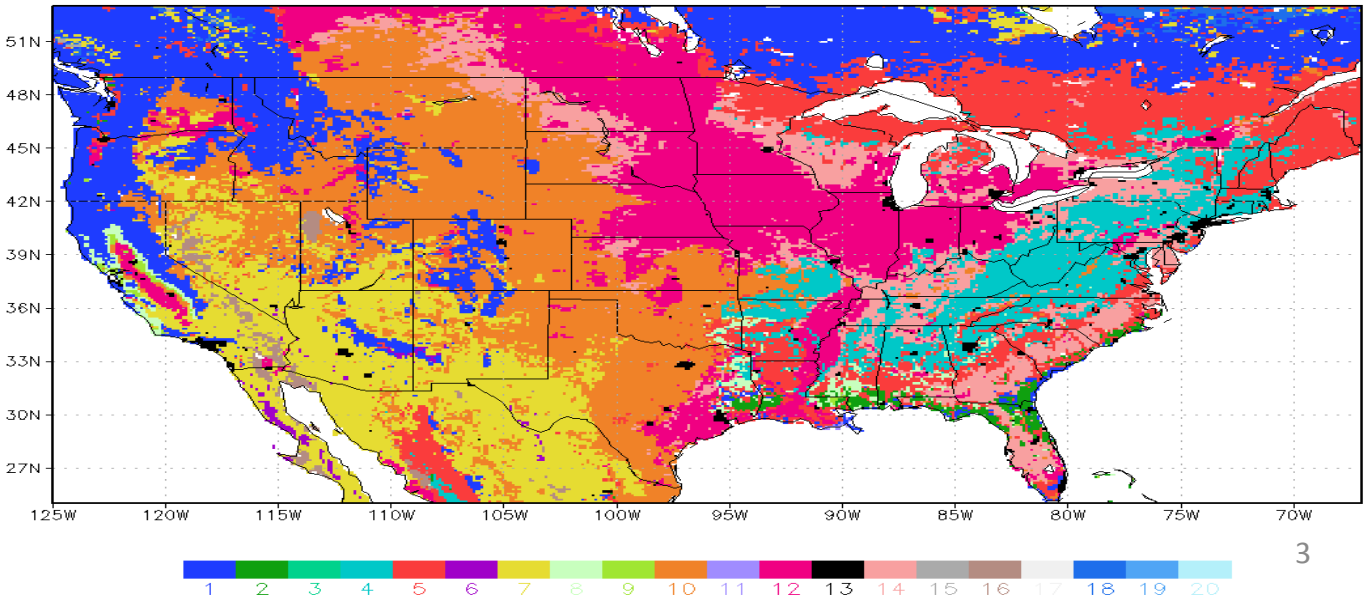
1: broadleaf-evergreen trees
2: broadleaf-deciduous trees
3: broadleaf and needleleaf trees
4: needleleaf-evergreen trees
5: needleleaf-deciduous trees (larch)
6: broadleaf trees with groundcover
7: groundcover only (perennial)
8: broadleaf shrubs with perennial groundcover
9: broadleaf shrubs with bare soil
10: dwarf trees and shrubs with groundcover (tundra)
11: bare soil
12: cultivations (the same parameters as for type 7)
13: glacial ice

GFS SIB VTYPE T1534 **1 degree**



1: Evergreen Needleleaf Forest
2: Evergreen Broadleaf Forest
3: Deciduous Needleleaf Forest
4: Deciduous Broadleaf Forest
5: Mixed Forests
6: Closed Shrublands
7: Open Shrublands
8: Woody Savannas
9: Savannas
10: Grasslands
11: Permanent wetlands
12: Croplands
13: Urban and Built-Up
14: Cropland/natural vegetation mosaic
15: Snow and Ice
16: Barren or Sparsely Vegetated
17: Water
18: Wooded Tundra
19: Mixed Tundra
20: Bare Ground Tundra

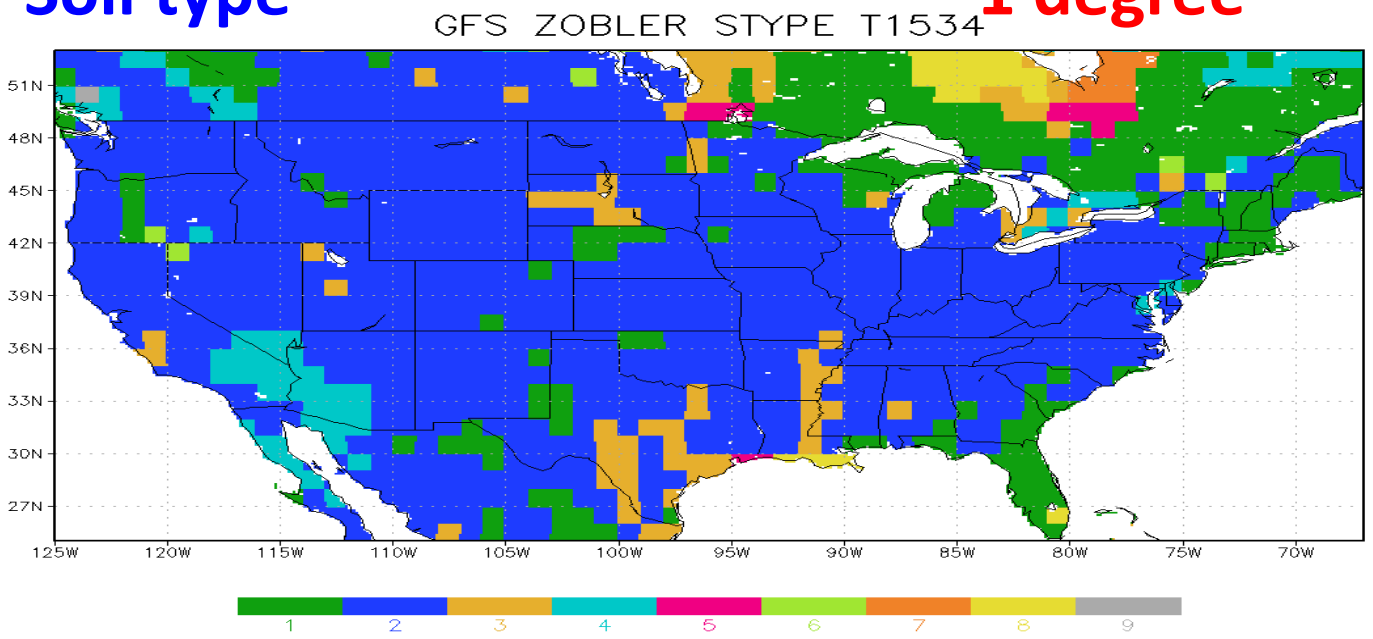
GFS IGBP VTYPE T1534 **1 km**



Soil type

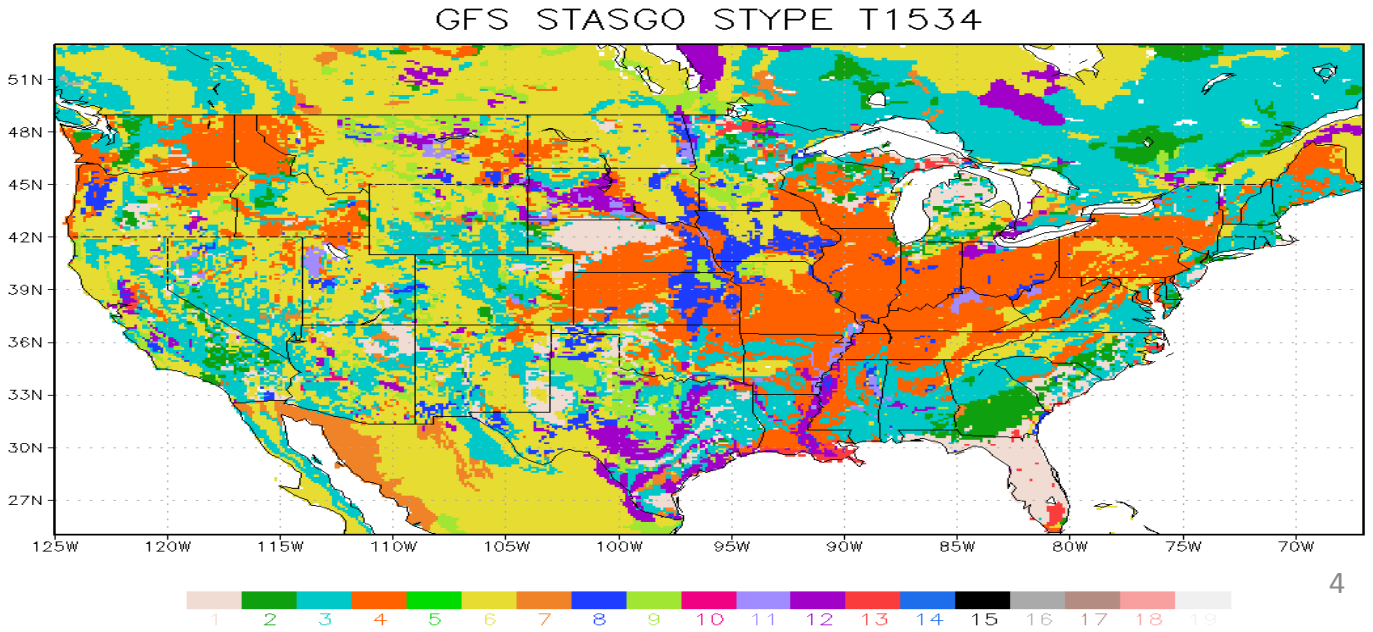
1 degree

1: loamy sand
2: silty clay loam
3: light clay
4: sandy loam
5: sandy clay
6: clay loam
7: sandy clay loam
8: loam
9: glacial ice



1 km

1: sand
2: loamy sand
3: sandy loam
4: silt loam
5: silt
6: loam
7: sandy clay loam
8: silty clay loam
9: clay loam
10: sandy clay
11: silty clay
12: clay
13: organic material
14: water
15: bedrock
16: other (land-ice)
17: playa
18: lava
19: white sand



Improved Stable Surface Layer

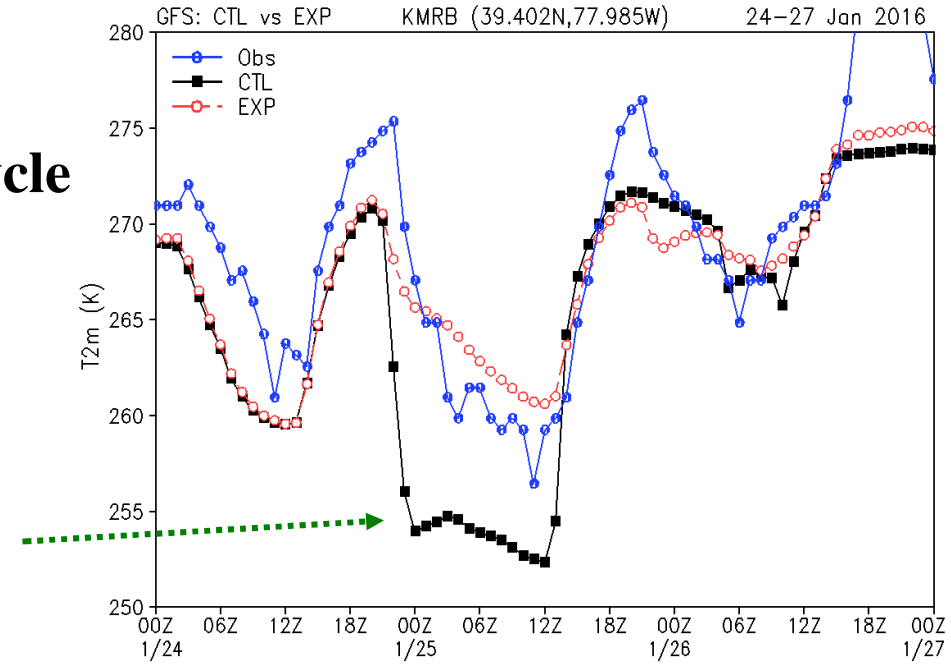
Introduction of a stability parameter constraint that prevents the land-atmosphere system from fully decoupling:

$$z/L < z/L|_M = \ln(z/z_0)/[2*\alpha*(1-z_0/z)]$$

Here z is the height, L is the Obukhov length, $z0$ is the momentum roughness length, and α=5.

GFS Test: 00Z, 2016-01-24 Cycle

T2m @ MRB Martinsburg RGNL, WV



CTL: Rapidly cooling more than 15 °C during 3hr;
EXP: Substantially improved

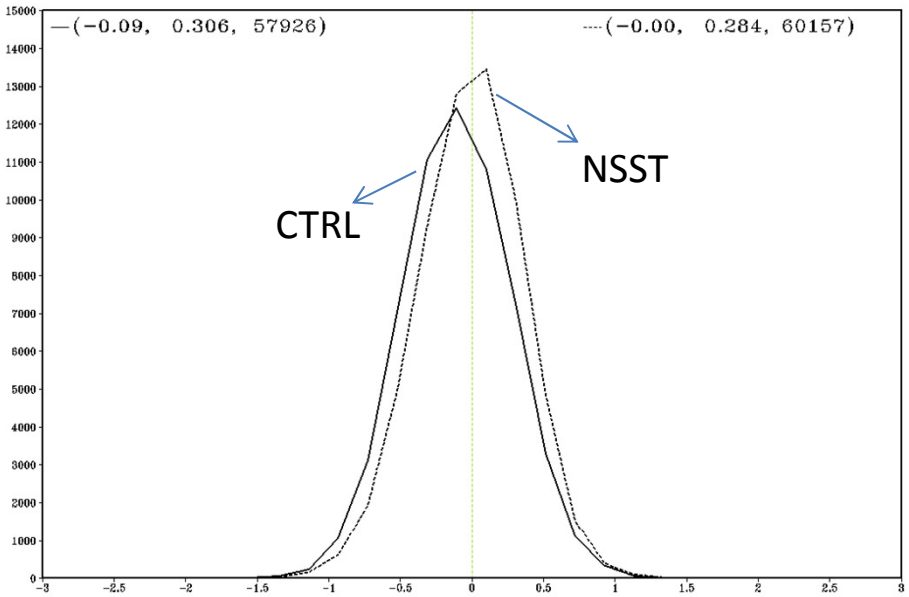
Updates Cumulus Convection Schemes with Scale and Aerosol Awareness

- Scale-aware, aerosol-aware parameterization
- Rain conversion rate decreases with decreasing air temperature above freezing level.
- Convective adjustment time in deep convection scheme proportional to convective turn-over time with convective available potential energy (CAPE) approaching zero after adjustment time.
- Cloud base mass flux in shallow convection scheme function of mean updraft velocity.
- Convective inhibition (CIN) in the sub-cloud layer additional trigger condition to suppress unrealistically spotty rainfall especially over high terrains during summer
- Convective cloudiness enhanced by suspended cloud condensate in updraft.
- Significant improvement especially CONUS precip in summer.

The NSST Model

- **Near-Surface Sea Temperature describes oceanic vertical temperature structure near surface due to the diurnal warming and sub-layer cooling physics processes**
- **SST, satellite data assimilation, and weather forecasting improved by analyzing SST together with atmospheric analysis variables with advanced GSI data assimilation techniques and resolving SST diurnal variability in the prediction**

Fig.1 (O-B) Histogram for one IASI window channel, 10-day statistics. Improved by NSST in bias, rms and number of used data



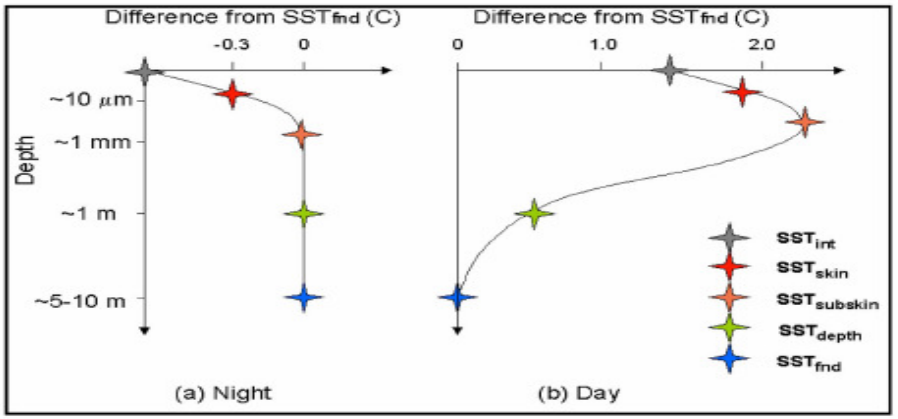


Fig. 1. Schematic showing (a) idealized nighttime vertical temperature deviations from the foundation SST and (b) idealized daytime vertical temperature deviations from the foundation SST in the upper ocean. From Donlon and the GHRSST-PP Science Team (2005). Courtesy of C. J. Donlon.