Status of the TM5 adjoint model

The latest (but not necessarily the greatest) TM5 4DVAR

Sourish Basu

SRON Netherlands Institute for Space Research

Universiteit Utrecht

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- Current adjoint model based on the ISPRA "t36" version, with Arjo's OpenMP modifications
- Modularized using python, called "PyShell" for want of a better name
- Can assimilate point and total column observations (profiles... not yet)

The class hierarchy (Emissions.py)

```
class Emissions:                                    # general class to read and write emission files for TM5
    def __init__(self, start_time, end_time):
        …
    def WriteEmissions(self):
        …

class CO2_Emissions_SiB(Emissions):                 # specific class to use SiB biosphere fluxes
    def CollectSiB(self, lat_lon_grid, period_start, period_end):
        …
```

Usage

```
# use CO2_Emissions_SiB as the class to assemble emissions
from Emissions import CO2_Emissions_SiB as Emissions
# specify the name of the optimizer class in the rc file instead of hardcoding it in the script
rcf = rc.RcFile(os.environ['pyshell.rc'])
opt_module = rcf.get('my.optimizer.class')
_temp = __import__('Optimizer', fromlist=[opt_module])
try:
    Optimizer = _temp.__dict__[opt_module]
except KeyError:
    sys.stderr.write("Class %s not defined in %s"%(opt_module,'Optimizer')) ; sys.exit()
```

The emission file structure

```
dimensions:
        itime = 6 ;
group: glb600x400 {
  dimensions:
        latitude = 45 ;
        longitude = 60 ;
  group: total {
    dimensions:
        nt = 31 ;
    variables:
        short time_start(nt, itime) ;
        short time_end(nt, itime) ;
        double emission(nt, latitude, longitude) ;
    // group attributes:
                :time_resolution = "daily+7 " ;
                :optimize = 1 ;
    } // group total
  } // group glb600x400
group: sea300x200 {
  dimensions:
        latitude = 24 ;
        longitude = 28 ;
```

The emission file structure (contd.)

```
group: rest {
  dimensions:
      nt = 7 ;
  variables:
      short time_start(nt, itime) ;
      short time_end(nt, itime) ;
      double emission(nt, latitude, longitude) ;
  // group attributes:
              :time_resolution = "monthly " ;
              :optimize = 0 ;
  } // group rest
group: biomass\ burning {
  dimensions:
      nt = 71 ;
  variables:
      short time_start(nt, itime) ;
      short time_end(nt, itime) ;
      double emission(nt, latitude, longitude) ;
  // group attributes:
              :time_resolution = "daily+3 " ;
              :optimize = 1 ;
  } // group biomass\ burning
```

Sub-daily temporal variation (unoptimized)

```
group: glb600x400 {
  group: total {
    dimensions:
        timesteps = 8 ;
    variables:
        double emission_anomaly(timesteps, latitude, longitude) ;
    } // group total
  } // group glb600x400
group: sea300x200 {
  group: biomass\ burning {
    dimensions:
        timesteps = 24 ;
    variables:
        double emission_anomaly(timesteps, latitude, longitude) ;
    } // group biomass\ burning
  group: rest {
    dimensions:
        timesteps = 8 ;
    variables:
        double emission_anomaly(timesteps, latitude, longitude) ;
    } // group rest
  } // group sea300x200
```

- Commit my tree to SVN, then...
- André Butz at KIT coded multi-species 4DVAR, Sander developed further
- Idea is to invert (for example) XCH_4:XCO_2 ratio, or jointly invert CO and CO_2
- Build in cross-species source correlation
- This is still being developed and tested

- Realistic flux correlation can be derived from an ensemble of priors, need a way to use that
- Correlation between observations due to transport can be estimated by using different instances of transport, need a way to use those
- Ongoing work with André Butz