Original Data

Dimensions

Initial: I = 122

i_1 = 2019-06-01T00:00:00.000000000

i_2 = 2019-06-02T00:00:00.000000000

…

i_{122} = 2019-09-30T00:00:00.000000000

Saildrone ID (traj): K = 6

Lead time (time): T = 61

t_1 = 0.0

t_2 = 0.25

…

t_{61} = 15.0

Number: N = 50

Data Variables

Prediction (i, k, t, n) - ensemble members

Observation (i, k, t) - saildrone

Error (i, k, t, n) - ensemble error

Obs_std (i) - observed standard deviation

Em (i, k, t) - ensemble mean

Sqe (i, k, t) - squared error ?

S (i, k, t) - ?

Processed Forecast Data

Let F(i, k, t, n) be the original forecast data

i: initial time

k: saildrone ID

t: lead time

n: ensemble members

Let $F_i(k, t, n)$ be the original forecast data averaged over I

$$F_i(k, t, n) = \sum_{i=1}^{I} F(i,\ k,\ t,\ n)\ /\ I$$

Let $F_k(i, t, n)$ be the original forecast data averaged over K

$$F_k(i, t, n) = \sum_{k=1}^{K} F(i,\ k,\ t,\ n)\ /\ K$$

Let $F_t(i, k, n)$ be the original forecast data averaged over T

$$F_t(i, k, n) = \sum_{t=1}^{T} F(i,\ k,\ t,\ n)\ /\ T$$

Let $F_n(i, k, t)$ be the original forecast data averaged over N

$$F_n(i, k, t) = \sum_{n=1}^{N} F(i,\ k,\ t,\ n)\ /\ N$$

Let $F_{i,k}(t, n)$ be the original forecast data averaged over I and K

$$F_{i,k}(t, n) = \sum_{i=1}^{I} \sum_{k=1}^{K} F(i, k, t, n) / IK$$

Let $F_{k,n}(i, t)$ be the original forecast data averaged over K and N

$$F_{k,n}(i, t) = \sum_{k=1}^{K} \sum_{n=1}^{n} F(i, k, t, n) / KN$$

Let $F_{i,k,n}(t)$ be the original forecast data averaged over I, K, and N

$$F_{i,k,n}(t) = \sum_{i=1}^{I} \sum_{k=1}^{K} \sum_{n=1}^{N} F(i, k, t, n) / IKN$$

Let $F^{i,k}_{n}(t_j)$ be the original forecast across all I and K, averaged over N, for a given lead time t=j where J=IKN

Let $F^{i,k,n}(t_j)$ be the original forecast across all I, K, and N for a given lead time t=j where J=IKN

Processed Saildrone Data

Let O(i, k, t) be the original saildrone data

i: initial time

k: saildrone ID

t: lead time

Let $O_i(k, t)$ be the original saildrone data averaged over I

$$O_i(k, t) = \sum_{i=1}^{I} O(i, k, t) / I$$

Let $O_k(i, t)$ be the original saildrone data averaged over K

$$F_k(i, t, n) = \sum_{k=1}^{K} O(i, k, t) / K$$

Let $O_t(i, k)$ be the original saildrone data averaged over T

$$O_t(i, k) = \sum_{t=1}^{T} O(i, k, t) / T$$

Let $O_{i,k}(t)$ be the original saildrone data averaged over I and K

$$O_{i,k}(t) = \sum_{i=1}^{I} \sum_{k=1}^{K} O(i, k, t) / IK$$

Let $O^{i,k}(t_j)$ be the original saildrone data across all I and K for a given lead time t=j where J=IK

Let $O^{STD}(i)$ be the given observed standard deviation

$O^{STD}(i)$ = obs_std(i)

Let $\overline{T_a}$ be the observed air temperature mean in degrees Celsius

$$\overline{T_a} = \sum_{i=1}^{I} \sum_{k=1}^{K} \sum_{k=1}^{T} T_a(i,\ k,\ t) \ / \ IKT$$

Let $\overline{T_s}$ be the observed sea surface temperature mean in degrees Celsius

$$\overline{T_s} = \sum_{i=1}^{I} \sum_{k=1}^{K} \sum_{k=1}^{T} T_s(i,\ k,\ t) \ / \ IKT$$

Let $\overline{sp}$ be the observed surface pressure mean in hPa

$$\overline{sp} = \sum_{i=1}^{I} \sum_{k=1}^{K} \sum_{k=1}^{T} sp(i,\ k,\ t) \ / \ IKT$$

Let $\overline{rh}$ be the observed relative humidity mean in %

$$\overline{rh} = \sum_{i=1}^{I} \sum_{k=1}^{K} \sum_{k=1}^{T} rh(i,\ k,\ t) \ / \ IKT$$

Calculations

Let $EF_{i,\,k}(t,\,n)$ be the error of ensemble members averaged over I and K

$$EF_{i,\,k}(t,\,n) = F_{i,\,k}(t,\,n) - O_{i,\,k}(t)$$

Let $EF_{i,\,k,\,n}(t)$ be the error of ensemble mean averaged over I, K, and N

$$EF_{i,\,k,\,n}(t) = F_{i,\,k,\,n}(t) - O_{i,\,k}(t)$$

Let $EF_{k,\,n}(i,\,t)$ be the error of ensemble members averaged over K and N

$$EF_{k,\,n}(i,\,t) = F_{k,\,n}(i,\,t) - O_{k}(i,\,t)$$

Let $RF^{i,\,k,\,n}(t_j)$ be the R correlation coefficient of the ensemble mean across all I, K, and N for a given lead time t =j where J = IK

$$RF^{i,\,k,\,n}(t_j) = \frac{J(\sum_{j=1}^{J} O(i,k,t_j)*F_n(i,k,t_j)) - (\sum_{j=1}^{J} O(i,k,t_j)\sum_{j=1}^{J}(F_n(i,k,t_j))}{\sqrt{(J(\sum_{j=1}^{J}(O(i,k,t_j)^2) - \sum_{j=1}^{J}(O(i,k,t_j))^2)((J\sum_{j=1}^{J}(F(i,k,t_j)^2) - \sum_{j=1}^{J}(F(i,k,t_j))^2)}}$$

Let $RF^{i,\,k}(t_j,\,n)$ be the R correlation coefficient of ensemble members across all I, K, and N for a given lead time t=j where J = IKN

$$RF^{i,\,k,\,n}(t_j,\,n) = \frac{J(\sum_{j=1}^{J} O(i,k,t_j)*F(i,k,t_j,n)) - (\sum_{j=1}^{J} O(i,k,t_j)\sum_{j=1}^{J}(F(i,k,t_j,n))}{\sqrt{(J(\sum_{j=1}^{J}(O(i,k,t_j)^2) - \sum_{j=1}^{J}(O(i,k,t_j))^2)((J\sum_{j=1}^{J}(F(i,k,t_j,n)^2) - \sum_{j=1}^{J}(F(i,k,t,n))^2)}}$$

Let $\overline{F^{i,\,k,\,n}(t_j)}$ be the mean of the original forecast across all I, K, and N for a given lead time t=j where M = IKN

$$\overline{F^{i,k,n}}(t_j) = \frac{1}{M}\sum_{m=1}^{M} F(i,\ j,\ n,\ k\ )$$

Let $F\_std^{i,k,n}(t_j)$ be the standard deviation of the original forecast across all I, K, and N for a given lead time t=j where J = IKN

$$F\_std^{i,k,n}(t_j) = \frac{\sqrt{\sum_{j=1}^{J}(F^{i,k,n}(t_j) - \overline{F^{i,j,k}}(t_j))^2}}{J-1}$$

Let $F\_MSE^{i,k}{}_n(t)$ be the mean square error of the ensemble mean across all I, K for a given lead time t=j where J = IK

$$F\_MSE^{i,k}{}_n(t_j) = \frac{1}{J}\sum_{j=1}^{J}(F^{i,k}{}_n(t_j) - O^{i,k}(t_j))^2$$

Let $F\_RMSE^{i,k}{}_n(t)$ be the root mean square error of the ensemble mean across all I, K for a given lead time t=j where j = IK

$$F\_RMSE^{i,k}{}_n(t_j) = \sqrt{F\_MSE^{i,k}{}_n(t_j)}$$

Specific Humidity Calculations

Lv=2.5×106 (Latent heat of evaporation, J kg-1)
MW=18.016 (Molecular weight of water, g mol-1)
R*=8.3145 (Universal gas constant (J K-1 kg-1)

Let $\overline{T\_K_a}$ be the observed air temperature mean converted to Kelvin

$$\overline{T\_K_a} = \overline{T_a} + 273.15$$

Let $\overline{T\_K_s}$ be the observed sea surface temperature mean converted to Kelvin

$$\overline{T\_K_s} = \overline{T_s} + 273.15$$

Let $\overline{sp}_{Pa}$ be the observed surface pressure mean converted to Pa

$$\overline{sp}_{Pa} = \overline{sp} * 100$$

Let e_{sa} be the saturation vapor pressure of the atmosphere in Pa

$$e_{sa} = 6.11\exp\left(\frac{L_V M_w}{1000R^*}\left(\frac{1}{273} - \frac{1}{\overline{T\_K_a}}\right)\right.$$

Let e_a be the vapor pressure of the atmosphere in Pa

$$e_a = e_{sa} * \frac{\overline{rh}}{100}$$

Let q_a be the specific humidity of the atmosphere and convert units from kg/kg to g/kg

$$q_a \approx w = \frac{0.622e_a}{\overline{sp}_{Pa} - e_a}$$